THE SCIENCE TEACHER

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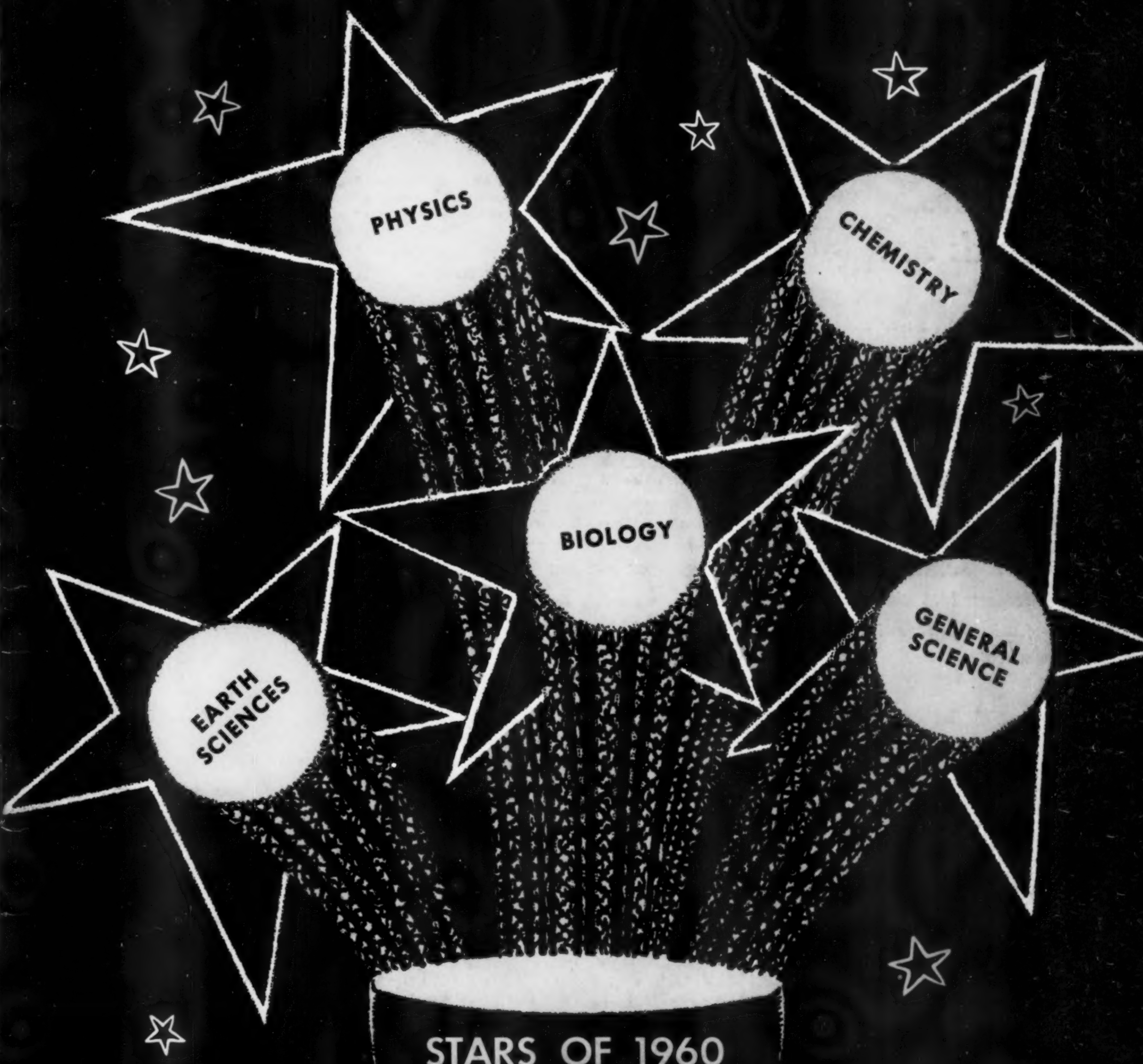

STARS OF 1960

THE SCIENCE TEACHER

The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

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We have been reporting periodically on special current programs in science curriculum development. As other programs develop and the information is made available to us, reports will be included in *TST*.

Many persons have expressed divergent views on the relative merits of these special programs, and in our society, this is as it should be. For many schools and teachers, however, the question is how do, or how should these curriculum developments affect us? What things should we consider before we either accept or reject one of the new curricula?

The products of the current curriculum projects should not be considered as the answer to the many problems in current science education. There are certain schools where the "new" course in physics would be completely out of place; there are other schools where every physics student should be enrolled in this course. If you accept that the curriculum might not be the correct "prescription" for all students, the first evaluative criterion that must be used is "objectivity." The curriculum should be objectively evaluated against the needs of the students. Teachers teach subject matters, true, *but* they teach it to students. If the subject matter and the students are incompatible, one or the other must be changed, and the boys and girls are enrolled in your school because they and their tax-paying parents *live* in the community.

Don't treat the new curriculum as a "sacred package." If the whole "curriculum package" is not suitable for your particular situation, perhaps part of it is. Use the course unit by unit and only those units that fit your students' needs. How many of you change the chapter order of, skip content in, or add to the content of the textbook you are currently using? Why should you feel any differently about the curriculum materials presently under development?

Some persons have voiced the objection that to do this changes the objectives of the course. Perhaps it does, and perhaps for your students the objectives of the course as it is developed need changing. *You* are using the curriculum in *your* classroom and not conducting it for the people who developed it. There is nothing that leads us to suspect that some curricula have a certain validity index and that by changing the content we change the validity. Even if there were, changing the curriculum to suit your needs will probably, for *your* purpose, increase this validity.

So far you have been advised to be cautious in considering a "new" curriculum. You should, however, also be open-minded. Since the development of these curricula was largely done by persons other than high school teachers, some teachers may conclude that these curricula are not for their students. Science teachers drawing such a conclusion without more data or evidence are arriving at an unscientific judgment.

Teachers using and evaluating new curricular ideas in the classroom are as true experimentalists as are any other research workers. All teachers wish to instill the spirit of the scientific process in their students. When students observe their teachers using the scientific process in evaluating a curriculum, this is setting an excellent example, and much effective learning can come about through example.

JOHN W. RENNER
Associate Executive Secretary

THE SCIENCE TEACHER

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MEMBERSHIP

The membership year extends for one year from date of enrollment. Subscriptions are entered for either the calendar year or the school year.

Regular Membership	$ 6.00
Sustaining Membership *	10.00
Student (college and university) Membership	2.00
Life Membership * Payable in ten annual installments; $150 if paid in three years or less.	175.00
Library Subscriptions *	8.00

* Includes the *Elementary School Science Bulletin* published monthly from September through April of each year.

I have just completed reading the September 1959 issue of *The Science Teacher*. It's a wonderful and inspiring publication. I didn't know that I was missing such a wealth of information until I read it.

If it is at all possible, will you please send me the copies that I have missed for the school year 1959-60.

MARTHA H. WILKERSON
2755 East First Street
Fort Worth, Texas

Congratulations on the new format for *The Science Teacher*. According to my usual practice, I picked the magazine up and started flipping from the back and began to notice the change right away. Your presentation of articles and the more sprightly editorial style are quite noticeable. It is a distinct improvement, and you should benefit greatly from it.

ROBERT F. GOULD
Assistant to the Editorial Director
American Chemical Society
Washington, D. C.

Congratulations on the February issue of *The Science Teacher*, which I have just received. The larger format is handled beautifully. It will now be the more painful for me to see issues of the journal without a Van Nostrand ad.

GEORGE W. BAUER
Advertising Department
D. Van Nostrand Company, Inc.
Princeton, New Jersey

I like the magazine and other services received. I am placing my accumulated copies in our Ferris Institute library for the use of our prospective science teachers.

ALAN E. VAN ANTWERP
116 Rust Avenue
Big Rapids, Michigan

May I comment briefly on the new format of your magazine. Frankly, I am disappointed with the change. It seems to me that an attempt has been made to provide a magazine in the "popular style." Its larger size makes it more difficult to file on bookshelves, while in content it is full of distracting advertising scattered throughout the magazine. If only the advertising were placed at the front or the back as in most intellectual magazines the advertising would not be so objectionable. Surely the placement of the advertising distracts seriously from the usefulness of the magazine.

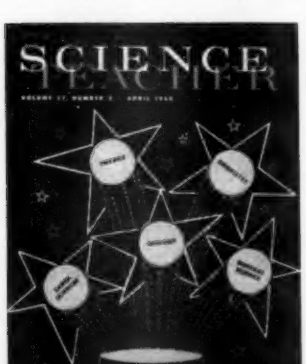
May I add that the journal of your companion association, the National Council of Teachers of Mathematics, represents my ideal of a professional magazine for teachers. Of course, I would expect more illustrations and somewhat more advertising in a science magazine than in one dealing with mathematics.

L. W. KUNELIUS
Inspector of High Schools
Government of the Province of Alberta
Calgary, Alberta, Canada

Hearty congratulations on the great improvement in *The Science Teacher's* format and typography. Although the journal has always been my first reading love, your 1960 approach might well be said to pace many other good things which are to come in this decade.

The Association is to be complimented for such a fine job.

JAMES R. IRVING
Executive Secretary
Laboratory Equipment Section
Scientific Apparatus Makers Association
Chicago, Illinois



THIS MONTH'S COVER. . .

Light and energy received from the stars are essentially produced as a result of a nuclear process. As the process occurs, temperatures rise to a hundred million degrees, particles in radiating streams collide at tremendous velocities, and new particles are formed. So it is with the STARS of 1960. New ideas are formed, collide, emerge, and extend to influence all areas of science teaching.

STA

SR. MARY HERMIAS MENNEMEYER, S.S.N.D.

Let those who are in
favour with their Stars
Of public honour and
proud titles boast.

Shakespeare, *Sonnet*

THE winners of NSTA's 1960 Science Teacher Achievement Recognition (STAR) awards may be justly proud of the public honors accorded them at the Kansas City convention and in the press, of the $13,500 in prize money which they pocketed, and, most of all, of the professional service they have rendered to their fellow teachers of science and their students.

It is not easy to become a STAR. Over 2500 teachers started the quest by writing in for entry forms and information. Nearly 400 carried through with submissions of reports on science teaching ideas they devised and then tested in the classroom. Two teams of judges read these reports with the utmost consideration of objectives and criteria for the program. The quality of the entries in STAR '60 was high and the competition was keen. Nevertheless, the judges came up with 56 winners of cash awards and 78 winners of meritorious citations.

The $1000 Award

The first-place award of $1000 went to **Sr. Mary Hermias Mennemeyer,** S.S.N.D., teacher of chemistry and physics at St. Francis Borgia High School, Washington, Missouri. Her entry, "Adventures in Radioactivity for High School Students," included a detailed account of some 80 experiments and projects with radioisotopes, many of them essentially of a junior research or "open-ended" laboratory activity. This project was stimulated by an Oak Ridge National Laboratory Summer Institute which Sr. Hermias attended, and was developed with the cooperation of Sr. Mary Joecile Ksycki, S.S.N.D., head of the chemistry department at nearby Notre Dame College, St. Louis, Missouri.

The STAR '60 program was designed, in part, to encourage collabora-

SR. MARY KSYCKI

ARS OF 1960

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tion of scientists and science teachers in the development of science teaching ideas. It is noteworthy, therefore, that the top award-winning entry was a joint effort. Only seven such projects, however, were among the 56 which won cash awards, and one was among the honorable mention citations.

The $500 Awards

Winners in the $500 category represented a diverse array of new approaches in teaching science—ERMA, the Electronic Review Motivating Automaton; devices for air-age studies; a school planting project of a "world court of trees" with data from United Nations countries; and a study of organic coatings for metals are examples.

Winner of $500 and also the Bausch & Lomb Microscope for the top entry in the field of biology was a collaborative project submitted by Mrs. Carolyn A. Gibson of North Hills High School, Pittsburgh, Pennsylvania. The cooperating scientist was Dr. John R. Jablonski of the University of Pittsburgh School of Medicine. This report centered on a high school student team studying various aspects of cancer. Names of the STARS of 1960 and the titles of their reports are listed on the following pages.

The STARS Themselves

Where do the STARS come from, and what kind of teachers are they? The winners of the 11 top awards included 3 from California, 2 from New York, 2 from Arizona, and 1 each from Missouri, Pennsylvania, Texas, and Ohio. When all 56 cash award winners are considered, 25 states are included in the honor roll. Two states alone accounted for 20 of these winners—New York with 11, and California with 9; Massachusetts and Ohio came next with 3 each. Fourteen more states, bringing the grand total to 39, plus the District of Columbia and Japan, complete the roster when winners of meritorious citations are included.

Ten of the 56 entries which won cash awards were submitted by women, three of whom were Catholic Sisters. Ten of these top entries related to the junior high school level. Biology outstripped all other fields as the central discipline for the projects, there being 27 winners in this area. Physics was next with 13 successful entries, followed by chemistry with 5.

Selection of STARS

Judging and selection were rigorous but procedures were planned and directed impartially keeping the objectives and criteria as outlined in the STAR '60 brochure in sharp focus. A first-round review of all entries was conducted by a judging team comprised of 19 individuals—5 teachers from junior and senior high schools, 9 government or university scientists, and 5 persons serving in administrative posts in science education. This group narrowed the entries from nearly 400 to a selected group of 150 for final judging. Members of the National and Advisory Committees for STAR '60, augmented by four other persons, made the final choices. During these two judging operations, all papers emerging on lists as winners and meritorious citations were read and evaluated independently by at least ten judges. Many of the 56 winners were present at the Kansas City convention to receive their checks and bronze medallions. Trophy case plaques, engraved with the names of all winners, have been sent to their respective schools.

Radiations from the STARS

There is no doubt that the influence of this STAR program, as with others in the past, will extend far beyond mere recognition of 56 science teachers. The excellent work of these teachers and of other entrants in STAR '60 will radiate to inspire and help thousands more through an NSTA publication which will present many of their science teaching ideas. Expected to be off the press early in the fall, copies of this publication will be sent free to all NSTA Life and Sustaining members and to library subscribers. Additional copies will be available to others as a sales item. Other STAR '60 reports will

IRA FINKEL

be reviewed for possible publication in future issues of *The Science Teacher*.

Appreciations

On behalf of the Board of Directors and staff of NSTA, sincere thanks and appreciation for professional service are extended to all who have helped make STAR '60 a success—the National Cancer Institute for its sponsorship and financial support; the 400 entrants who activated the program; the National and Advisory Committees who shaped the program design and supervised its course of development; the more than 20 judges who gave over 30 hours each in evaluating the entries; Mr. Robert H. Carleton, Executive Secretary of NSTA, and Dr. Abraham Raskin, Professor of Physiology at Hunter College, New York City, who have served as director and secretary-editor, respectively, for all three STAR programs of 1956, 1958, and 1960.

HONOR ROLL

$1000 AWARD

Sr. Mary Hermias Mennemeyer, S.S.N.D., St. Francis Borgia High School, Washington, Mo.; Scientist collaborator: **Sr. Mary Joecile Ksycki, S.S.N.D.,** Notre Dame College, St. Louis, Mo. *"Adventures in Radioactivity for High School Students."*

$500 AWARDS

Ira Finkel, Island Trees High School, Levittown, N. Y. *"World Court of Trees."*

Carolyn A. Gibson, North Hills High School, Pittsburgh, Pa.; Scientist collaborators: **John R. Jablonski** and **Joseph H. Sunder,** University of Pittsburgh, Pittsburgh, Pa. *"Cancer Research Team of North Hills High School Biology Students Cooperating with the Addison M. Gibson Laboratory, School of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania."*

Paul D. Merrick and **Jerrett W. Rollins,** Carlmont High School, Belmont, Calif. *"Quantitative Reaction of Magnesium Ribbon with Oxygen."*

Charles W. Owens, Jr., Crozier Technical High School, Dallas, Texas. *"A Study of Organic Coatings."*

Stanley C. Pearson, Pasadena City Schools, Pasadena, Calif. *"Light Ray Tracer."*

Harvey Pollack, Forest Hills High School, Forest Hills, N. Y. *"ERMA (Electronic Review Motivating Automaton)."*

David T. Smith, Catalina High School and Tucson District No. 1, Tucson, Ariz. *"Devices for an Air Age Study."*

Thomas E. Thorpe, Jr., West High School, Phoenix, Ariz. *"Project Pendulum."*

JOHN R. JABLONSKI

CAROLYN A. GIBSON

JOSEPH H. SUNDER

Harry K. Wong, Menlo-Atherton High School, Atherton, Calif. *"A Mathematical Approach Toward Geotropism."*

S. Alton Yarian, Emerson Junior High School, Lakewood, Ohio. *"Give Them a 'See'."*

$250 AWARDS

Frederick R. Avis, Saint Mark's School, Southborough, Mass. *"Part I—A Presentation of Experiments for Secondary School Students in the Field of Muscle-Nerve Physiology. Part II—A Description of the Recent Addition to Our Laboratory Which Makes It Possible for the Secondary School Student to Experience Actual Advanced Laboratory Work in Several Fields of the Biological Sciences."*

Marjorie P. Behringer, Alamo Heights High School, San Antonio, Texas. *"A Course of Study for Advanced Biology."*

Richard F. Blake, Stratford High School, Stratford, Conn. *"How to Teach 36 Hours a Day."*

Maurice Bleifeld, Benjamin Franklin High School, New York, N. Y. *"Learning About a Scientific Library."*

James V. DeRose, Chester High School, Chester, Pa. *"Principles of Measurement for Senior High School Students."*

Harold L. Eddleman, Salem-Washington Township High School, Salem, Ind.; Scientist collaborator: **A. E. Bell,** Purdue University, Lafayette, Ind. *"A Student-Teacher Research Team."*

Lola Jean Eriksen, Mountain View High School, Mountain View, Calif. *"Ecology: The Out-of-doors Is Our Classroom."*

PAUL D. MERRICK

Phillip R. Fordyce, Oak Park and River Forest High School, Oak Park, Ill. *"Taught, Tempered, and Tested Advanced Biology."*

Lester S. Hollinger, Glen Rock High School, Glen Rock, N. J. *"A High School Summer Science Program."*

Paul Kahn, Bronx High School of Science, Bronx, N. Y. *"Advanced Placement, Research, and Microbiology."*

William N. Nichols, Vermont College, Montpelier, Vt. *"Original and Revised Demonstrations to Illustrate Science Principles."*

Doris E. Oatman, Hoover High School, San Diego, Calif. *"Talented Science Students Participate in a Learning Experience and Provide a Service to Their Community."*

Nellie F. Shepard, Southington High School, Southington, Conn.; Scientist collaborator: **John Bradley Bulman,** Central Connecticut State College, New Britain, Conn. *"A Variation of Robert Andrews Millikan's Method for Determining the Electric Charge Carried by an Electron."*

Robert W. Stegner, East High School, Denver, Colo.; Scientist collaborator: **Erik K. Bonde,** University of Colorado, Boulder, Colo. *"The Regulation of Plant Growth."*

Francis J. St. Lawrence, Lakewood High School, Lakewood, Calif. *"The Case for the Home Laboratory."*

Robert G. Stryker, Rialto Junior High School, Rialto, Calif. *"Project Solar Water Heater: A Seventh Grade Research Program."*

JERRETT W. ROLLINS

Zachariah Subarsky, Bronx High School of Science, Bronx, N. Y. *"A Biology-Biochemistry Unit in the High School Biology Course—a Teaching Project."*

Katharine Tucker, Penfield Senior High School, Penfield, N. Y. *"A Revitalized Approach to the Teaching of Photosynthesis."*

Theodore H. Varbalow, Olney High School, Philadelphia, Pa. *"The Anatomy of a Research Project."*

David Webster, Lincoln Public Schools, Lincoln, Mass. *"Operation Salafreeze."*

$100 AWARDS

Flavin J. Arseneau, Arlington Heights High School, Fort Worth, Texas. *"Science Stimulation Research in the High School."*

Emma Wagoner Batts and **Robert L. Gantert,** Alexander Hamilton Junior High School, Seattle, Wash. *"Introduction to Radiation Biology."*

Joel Beller, Richmond Hill High School, Richmond Hill, N. Y. *"Open-End Eggsperiments."*

Matthew H. Bruce, Jr., DuBois Area High School, DuBois, Pa. *"Using the Cathode Ray Oscilloscope in the High School."*

Thomas G. Carlomagno, Fairlawn High School, Fairlawn, N. J. *"The Science Work-Experience Program."*

John D. Davis, Exeter High School, Exeter, N. H. *"Physiological Demonstration of the Quahog Heart: Apparatus and Techniques."*

Morris Frankston, Pacific Beach Junior High School, San Diego, Calif. *"A Simplified Method of Demonstrating Sodium Ion Movement Through the Glass of an Electric Light Bulb."*

Theodore J. Griffin, Sr., Opelousas High School, Opelousas, La. *"Radioisotopic Experiments."*

Isadore Halpern, Erasmus Hall High School, Brooklyn, N. Y. *"Simplified Techniques for Studying Fruit Flies."*

Thomas M. Haynes, George Washington High School, Indianapolis, Ind. *"An Environmental Study Designed to Stimulate Critical Thinking in Biology."*

Chester O. Hurd, Chillicothe High School, Chillicothe, Ohio. *"A Method to Enhance the Study of Vectors and Motion in High School Physics."*

Herman H. Kirkpatrick, Roosevelt High School, Des Moines, Iowa. *"Photography in the High School Physics Laboratory."*

Harold J. Levy, Sheepshead Bay High School, Brooklyn, N. Y. *"A Kymograph for Less than a Dollar."*

Arthur C. Murdock, Sutton High School, Sutton, Mass. *"The Teaching of General Science Through Experimentation."*

David E. Newton, Ottawa Hills High School, Grand Rapids, Mich. *"The Skill-Centered General Science Course."*

Thomas G. Overmire, Shortridge High School, Indianapolis, Ind. *"Mathematics in Biology."*

Margy E. Radecki, Baker High School, Columbus, Ga. *"Survey of Certain Natural and Community Resources in Muscogee County that Aid in Teaching Science in High School."*

Elsie S. Scott, Northfield School for Girls, East Northfield, Mass. *"Relative Humidity as a Key Concept in the Understanding of Weather, Air Conditioning, and Health."*

CHARLES W. OWENS, JR.

Victor M. Showalter, Fairmont High School, Kettering, Ohio. *"The Kettering Chemathon."*

Sr. Mary Paulinus, O.P., St. Mary High School, Cheyenne, Wyo. *"Research in the Hinterland."*

Sr. M. Henriella Reinders, F.S.P.A., Cathedral High School, Superior, Wis.; Scientist collaborators: **Sr. M. David Campi, P.B.V.M.,** Presentation Academy, San Francisco, Calif., and **Sr. M. Ignatiana Donaghue, I.H.M.,** St. Mary Convent, Monroe, Mich. *"Radiation Biology for Biology Students."*

Robert L. Stanger, Long Beach High School, Long Beach, N. Y. *"Aggressive Mice."*

Michael J. Stimac, S.M., St. Joseph High School, Cleveland, Ohio. *"Amateur Radio—Aladdin's Lamp for Teachers."*

Kenneth D. Wagner, Manual Arts High School, Los Angeles, Calif. *"Simplified Plastic Embedding for Teacher and Student."*

Gerrit C. Zwart, Suffern High School, Suffern, N. Y. *"The Graviplane."*

HARVEY POLLACK

MERITORIOUS CITATIONS

Norman Abraham, Yuba City Union High School, Yuba City, Calif. *"The High School Science Expedition—A 'Recipe for Research'."*

Bessie S. Abramovitz, West Philadelphia High School, Philadelphia, Pa. *"We've Reached the Heavens."*

Ruth H. Adams, Redlands High School, Redlands, Calif. *"A Field Approach to High School Biology."*

Owen N. Alberty, Beaverton High School, Beaverton, Ore. *"A Geology Detective Story."*

John A. Banasick, Southern Regional High School, Manahawkin, N. J. *"History of Science."*

Robert M. Barber, Thomas Jefferson Junior High School, Eugene, Ore. *"A Science Survey."*

Alfred Bender, Stuyvesant High School, New York, N. Y. *"The Working Classroom for the Bright Student."*

Percy F. Benedict, Tilton School, Tilton, N. H. *"An Approach to the Study of Physics."*

Wilbert L. Braxton, William Penn Charter School, Philadelphia, Pa. *"An Analysis of the Motion of a Falling Body."*

Stanley R. Breckner, Southwest Junior High School, Albert Lea, Minn. *"Exploratory Experiences in Ninth Grade Physical Science—A Laboratory Manual and Workbook."*

Brother Wendel Adam, C.S.C., Holy Cross High School, New Orleans, La. *"Moonwatch Participation by High School Science Students."*

Brother Julian E. Roy, Mt. St. Michael High School, New York, N. Y. *"How to Build and Demonstrate a Classroom Transmitter."*

Charles A. Browning, East High School, Knoxville, Tenn. *"Original Method for Determining the Duration of the Retinal Impression on the Human Eye."*

Richard W. Burkey, Derby High School, Derby, Kans. *"Experiment on Momentum."*

William C. Carden, Mt. Miguel High School, Spring Valley, Calif. *"Experimental Biology II."*

George P. Carpenter, Wayland High School, Wayland, Mass. Two projects: *"Course in Electronics;* and *Unit in Physical Chemistry."*

Ernest J. Ceragioli and **Paul F. Robloff,** Mount Vernon School, Chicago, Ill. *"Geology of Chicago Area."*

Gabriel J. Damico, Smedley Junior High School, Chester, Pa. *"Balloon Meteorology."*

L. Dale Davison, Marion-Harding High School, Marion, Ohio. *"An Optics Box."*

Daniel L. Dindal, Worthington High School, Worthington, Ohio. *"Ecology Studies in High School Biology."*

Oliver W. Eason, Cedar Falls High School, Cedar Falls, Iowa. *"Vectors in High School."*

Clair W. Elmore, Santa Rosa High School, Santa Rosa, Calif. *"A Periodic Table Designed for Teaching."*

Max C. Epstein, New Utrecht High School, Brooklyn, N. Y. *"The Chemical-Amie-Maker."*

David L. Fagle, Marshalltown High School, Marshalltown, Iowa. *"Bacteriology Available to Everyone."*

Thaddeus B. Fowler, Point Pleasant Beach High School, Point Pleasant Beach, N. J. *"The Use of Automatic Demonstrations in the Science Classroom."*

Robert L. Gantert, Alexander Hamilton Junior High School, Seattle, Wash. *"Strange as It Seems in Biology."*

Jeanne L. Gelber, Robert E. Lee High School, Baytown, Texas. *"The Teacher, a Catalyst in the Development of Youthful Scientists."*

Harvey J. Goehring, Jr., Penn Hills Senior High School, Pittsburgh, Pa. *"The Development of Critical Thinking in the Physics Laboratory."*

STANLEY C. PEARSON

Norman N. Goldstein, Jr., Sir Francis Drake High School, San Anselmo, Calif. *"Use of the Tape Recorder as a Technique for the Improvement of Learning and Teaching."*

Meyer L. Gottlieb, De Witt Clinton High School, Bronx, N. Y.; Scientist collaborator: **George S. Snell,** Roscoe B. Jackson Laboratory, Bar Harbor, Maine. *"An Integrated Year-round Pupil-Teacher-Scientist Program in Experimental Biology."*

William S. Green, North High School, Denver, Colo., and **Eugene H. Herrington,** Palmer School, Denver, Colo. *" 'BG' Science Wheel."*

Richard W. Guyer, Thomas Carr Howe High School, Indianapolis, Ind. *"Let's Integrate the Yards-Park Program into the Biology Curriculum."*

Doris E. Hadary, North Bethesda Junior High School, Bethesda, Md. *"Ninth Grade Laboratory Science, a Backbone to Build On."*

Sidney P. Harris, Bayside High School, Bayside, N. Y. *"A Gravimetric Approach for the High School Chemistry Laboratory at Negligible Expense."*

DAVID T. SMITH

Alexander Haslam, St. Alban's School, Washington, D. C. *"A Comprehensive Program for Grades Four Through Eight."*

Thomas M. Haynes, Washington High School, Indianapolis, Ind. *"Life in the Soil Depths."*

Paul L. Hunsberger, Kutztown Area Junior High School, Kutztown, Pa. *"Astronomy 1959."*

Paul A. Johnson, Abraham Lincoln Junior High School, Rockford, Ill. *"How to Teach the Barometer and Give It Meaning."*

Norbert J. Konzal, Phoenix Union High School, Phoenix, Ariz. *"An Experiment: The Use of Radioactive Phosphorus to Trace the Path of Minerals and Water to the Leaves of Plants."*

Edward G. Kreppert, Palm Springs Junior High School, Hialeah, Fla. *"Teaching by Analysis of a Current Popular or Semi-Popular Magazine or Newspaper Article."*

THOMAS E. THORPE, JR.

Clifford T. LaRoge, Normandy High School, St. Louis County, Mo. *"Microchemical Projection."*

George L. Lehmberg, Spring Valley Senior High School, Spring Valley, N. Y. *"Peg-Board Demonstrator."*

Edmond C. Lonsky, Plainfield High School, Plainfield, N. J. *"Continuity in Physics Laboratory Work Through the Use of Graphs."*

H. M. Louderbach, Lewis & Clark High School, Spokane, Wash. *"A Spokane Summer Enrichment Program in Science."*

Henry C. Martin, Palo Alto Senior High School, Palo Alto, Calif. *"The High School Science Seminar."*

Robert C. Morris, York Community High School, Elmhurst, Ill. *"Suggestions for Increasing Respect for Basic Research Through Science Teaching."*

Arthur C. Murdock, Sutton High School, Sutton, Mass. *"A High School Experiment to Demonstrate the Application of Statistics to Research."*

Hyland D. Packard, Port Sulphur High School, Port Sulphur, La. *"Paper Chromatography."*

Laurence B. Perry, Manchester High School, Manchester, Conn. *"More Efficient Chemistry Instruction."*

Robert F. Porter, Burlington-Edison High School, Burlington, Wash. *"The Synthesis of Iodic Acid and the Effect of Its Concentration on the Speed of Reaction as Measured in Reciprocal Time."*

Al G. Renner, Eliot Junior High School, Altadena, Calif. *"An Improved Block-and-Breadboard Technique for Teaching Basic Electronic Experiments."*

Morton S. Roggen, Erasmus Hall High School, Brooklyn, N. Y. *"Biology in the Home — An Extended Laboratory Approach."*

James A. Rossas, Oroville High School, Oroville, Calif. *"Analogue Experiments Using Curtain Contours."*

Charlotte M. Scappucci, Charlotte Country Day School, Charlotte, N. C. *"The Science Roundtable."*

V. Theodore Schreiber, Rothrock High School, McVeytown, Pa. *"Planet X Project."*

Robert L. Silber, Central High School, Evansville, Ind. *"The Science Department: A Promoter of Interdepartmental Cooperation."*

Sr. M. Ambrosia, I.H.M., Holy Redeemer High School, Detroit, Mich. *"Buoyancy: An Introduction to Many Basic Physical and Mathematical Concepts."*

Sr. William Susannah Harahan, S.N.D., Notre Dame High School, Moylan, Pa. *"Radioactivity, Alpha, Beta, Gamma."*

Sr. M. Wilfreda Stump, Ad. PP.S., Sacred Heart Academy, Wichita, Kans. *"The Largest Biology Lab—The Great Out-of-Doors."*

Sr. Mary Emilia Weiler, St. Agnes Academy, Alliance, Nebr. *"That 'General Science' Problem."*

John E. Smith, Nyack High School, Nyack, N. Y. *"Raising the General Level of Science Instruction."*

HARRY K. WONG

William M. Smith, Thomas Carr Howe High School, Indianapolis, Ind. *"Biology III, An Advanced Course for the Senior High School."*

S. ALTON YARIAN

Laurence E. Snyder, Paradise Junior-Senior High School, Paradise, Calif. *"Experiments Involving Quantitative Aspects of High School Biology."*

Robert L. Stanger, Long Beach High School, Long Beach, N. Y. *"I Can Demonstrate Epilepsy and Its Treatment in Class."*

Charles W. Stonebarger, University Lake High School, Hartland, Wis. *"On Building Bridges."*

Arthur G. Suhr, Jefferson High School, Jefferson, Wis. *"Demonstrations and Activities for Teaching Astronomy."*

Kenneth J. Torgerson, Doolen Junior High School, Tucson, Ariz. *"A Problem Method of Teaching Eighth Grade Science."*

Raymond W. Traynor, Burbank Senior High School, Burbank, Calif., and **Robert J. Woodhead,** Sutter Union High School, Sutter, Calif. *"An Inexpensive Student-type Spectroscope."*

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Research for High School Science Teachers

By DONALD A. SCHAEFER

Science Teacher, Bettendorf Senior High School, Bettendorf, Iowa

MOST of us who teach high school science often discuss research and research methods. Many of us, however, have never had the time nor the opportunity to do individual research. In our undergraduate work, the time has been primarily consumed in required course work for a particular degree designation, and as many hours as possible are devoted to subject-matter courses in our chosen fields. In recent years, the weakness in subject-matter training has been corrected to a great extent by Summer Institute Programs in the subject-matter areas. This writer, like so many others, has been privileged to attend many of these Institute Programs, and has thus been allowed to increase subject-matter competence in a way which would have been otherwise impossible. In none of these programs, however, was there time or opportunity to do research.[1]

Here at Bettendorf Senior High School, an advanced group of science students have the opportunity and the requirement of individual research. This is as a regular part of their course, though all work on their research projects must be done outside of class time.[2] As the teacher and project advisor for this group of students, I have experienced the students' need for help in acquisition of research information. Though this part of our own science program may not be representative of the majority of schools, it is the opinion of this writer that it may well be in the not too distant future. Even without an advanced science course, the practice of doing a research project (by the student) is becoming increasingly com-

[1] Institutes attended by author at Carnegie Institute of Technology, 1952; University of Wisconsin, 1956-57; Michigan State University, 1957; and Reed College, 1958.

[2] Donald A. Schaefer. "Advanced Science for Gifted Students." *The Science Teacher,* 25:269. September 1958.

mon. The greater number of regional and local science fairs and the increase of entries in such national competitions, as the National Science Talent Search and the Future Scientists of America, indicate the increasing demands for knowledge of research placed upon the average teacher.

Last summer (1959), the opportunity to do nine weeks of uninterrupted research was afforded thirteen high school and small college teachers of science. The National Science Foundation awarded grants to this group for work at the Denver Research Institute, and to seven more teachers in the same category for similar work in various laboratories of the University of Denver. Each participant was placed largely on his own in research for the first time, and was assigned to a particular project on the basis of his own background and special interests. The projects were both of the "pure" and "applied" variety, and ranged from "A study of radiation in the upper atmosphere" and "Microminiaturization" to "The plastic deformation of hyper-velocity particles." Some participants worked as part of a research team on a project already under way, while others worked primarily on their own projects devised just for this program. Research scientists were assigned each participant in the role of project advisor, and worked in varying degrees with that participant through the entire nine-weeks program.

Since the project for which the author was selected was "An X-ray diffraction analysis of solid products formed in the thermal decomposition of aluminum nitrate nonahydrate," the advisors were research specialists in this general area. Dr. H. P. Leighly, head of the graduate metallurgy department at Denver University and a research metallurgist at DRI, and Robert McCune, head of the X-ray Laboratories at the Denver Research Institute, were assigned as advisor and project supervisor, respectively.

Exactly how did they supervise the work of this writer, and thus carry out a task similar to the work we would do with our students? A month before the program began, Dr. Leighly sent this writer an excellent text on X-ray diffraction,[3] in which he pointed out the key problems which illustrated basic concepts to be mastered. Since the X-ray diffractometer was the primary instrument to be used in the particular research study, and since Dr. Leighly realized that this writer had never previously worked with such an instrument, he chose the most efficient method to insure acquisition of necessary background. Some of these problems were worked and returned to him for correction and criticism. In this way, it is the feeling of the author that approximately two-weeks time was saved in acquiring necessary background, and this two weeks was invaluable as the work advanced.

Upon arrival at DRI, the first man this writer met was none other than Dr. Leighly. He had anticipated the feelings of doubt and the misgivings of the participants about to embark on this new and intensive undertaking, and tried immediately to make DRI seem like home. Following a brief orientation period with the director of the entire program, Dr. Leighly introduced the author to Mr. McCune and conducted a brief tour of the laboratories, with introductions to all personnel. There was little doubt, after the first morning with these men, that they would do everything they could to make the research experience meaningful, and that as complete freedom as possible would be afforded.

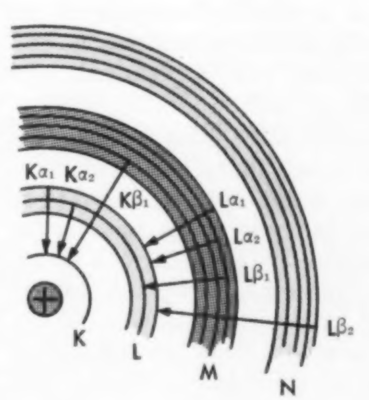
When one is first heading into a completely new experience, such as research, assurance and confidence provided, as well as a personal interest, are of great importance. The same uncertainty as mine must face our students as they begin thinking about doing a research project, and as they wonder if they have the capabilities to do successful research work. They need the same sense of assurance and confidence so ably conveyed by the advisors to me at DRI. Just as important is the understanding that, right from the start, the thinking and work must be done by the student. *Freedom* to pursue the various avenues of a research problem must carry with it the *responsibility* for such pursuit, in order to achieve its purpose.

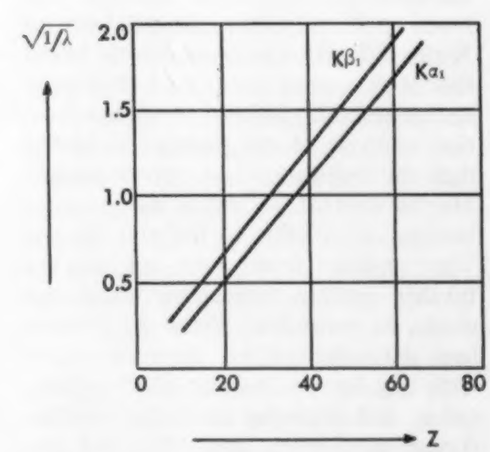
During the first week in the laboratory, direction was given in the specific use of the Norelco diffractometer. Mr. McCune furnished samples of materials with well-defined crystalline structure so that clear and easily identifiable diffraction patterns resulted. (Here the material of the text made it possible to become adept in a minimum of time.) By using such materials as titanium dioxide, corundum, etc., it was possible to focus complete attention on learning to operate the diffractometer and "read" diffraction patterns, since these patterns were clear and simple.

After the first week of orientation with the instrument and further study

FIGURE 1.

(a) Electron transitions and the corresponding radiations.





(b) Almost linear relation between $\sqrt{1/\lambda}$ and Z. In formula form, known as Moseley's law, and written: $\sqrt{\nu} = C(Z - \sigma)$ where C and σ are constants, and ν is the line frequency.

[3] B. D. Cullity. *Elements of X-Ray Diffraction.* Addison Wesley Publishing Company, Inc., Reading, Massachusetts. 1956. p. 505.

of the literature, as it pertained to aluminum compounds, a conference was held with the two advisors and Mr. George Rauscher (a graduate student who had completed a study of aluminum nitrate nonahydrate). At this conference, the author was informed of the specific tests that were performed by Mr. Rauscher, as well as the specific difficulties and results he was able to note. Numerous sources of information were also suggested at this conference from which more information could be obtained regarding work done on this study. Initial procedures for beginning the research study were also jointly decided upon and planned. The advisors were available during the project to aid in matters pertaining to background. They encouraged the author to determine the tests to be run and analyses to be made and, insofar as possible, made available any equipment or facilities needed for these tests.

In the following paragraphs, an attempt will be made to give the reader a feeling for the specific problem, background required, experimental procedure followed, and the conclusions this writer felt were warranted on the basis of experimental work done. An attempt will be made to correlate modified excerpts from a thesis report submitted (though not required) at the close of the program. Space will not permit any extensive coverage, but enough to present a clear picture.

Modified excerpts from research report of author. In August 1958, a sample of a corrosion product from an aluminum vat was sent, for analysis, to the Denver Research Institute X-Ray Laboratory. When an attempt was made to identify this material from an X-ray diffraction pattern, it was found that it was amorphous and thus gave no identifiable pattern. A decomposition analysis of the product indicated that the substance lost approximately 50 per cent of its initial weight after heating at 1000° C for two hours. The residue then gave an unmistakable pattern for alpha aluminum oxide, or corundum. Since the weight-loss data showed no correspondence with any known hydrate of aluminum oxide, and since the vat had contained concentrated nitric acid, Mr. McCune surmised that the initial sample *might* have been a hydrate of aluminum nitrate. Further correspondence with the sending organization revealed that the initial corrosion product had been heated overnight at approximately 100° C before it was sent. This presented the additional probability that the corrosion product itself could have been partially decomposed by the initial heating, and the sample received by the laboratory had actually been one of the early decomposition products of such a breakdown.

Mr. Rauscher, then beginning his thesis work for a Bachelor's Degree in Chemistry at the University of Denver, decided to concentrate on aluminum nitrate nonahydrate. He found that this compound was exceedingly difficult to work with, since it was highly deliquescent. During the time of a diffraction "run" the sample would pick up or lose water, depending upon the relative humidity of the surrounding air, and there was no way to be certain that it was the "same" material.

The additional facts that the decomposition of aluminum nitrate nonahydrate is likely to occur in steps, that the dissociation and recombination processes will occur simultaneously, and that amorphous intermediate products are possible and even probable, all add complications to such an analysis. Most sources indicate that the most profitable method in such cases is the loss of weight method, where the reaction is followed on a micro-balance.[4]

Because the water of hydration is not always held in the crystal lattice in the same way, different things may occur when the material is decomposed by heating. The lattice of the residue may be practically identical with that of the inorganic constituents of the original hydrate, as in the case of the zeolites; it may have a phase showing little evidence of crystalline structure at all; and finally, the dehydrated residue may crystallize to give an entirely new crystalline phase.[5]

Principles of X-ray diffraction. Though X-ray diffraction requires a crystalline nature in the material to be analyzed, and amorphous material (or material with crystallitic size of less than eighty Angstroms — approximately) does not produce a definitive pattern, it is regarded as one of the outstanding methods of solid-state analysis,[6] and most research studies substantiate its value.

FIGURE 2.

The author with Norelco diffractometer used in study.

A. Protective scatter-shield in which powder specimen is placed.

B. Scintillation counter, detector unit which scans region for diffracted beams and measures 2θ angles automatically.

C. Resultant graph of 2θ values versus an intensity measure.

D. Scaling unit and power unit for detector.

The basic principles involved in diffraction work concern the fundamental electromagnetic nature of X-radiation, and the phenomena of constructive and destructive interference resulting from monochromatic radiation being scattered from regularly recurring points. The X rays themselves result when outer adjacent electrons fall into spaces in inner shells from which these inner electrons have been ejected. When electrons of sufficient energy bombard an atom, an electron may be forcibly ejected from the K shell, and an electron from the M shell, or some higher shell, may then fall into the vacancy. No matter which particular electron falls to the lower energy level (K) vacancy, the emitted energy is quantized. If this were the only source of

[4] W. E. Garner, Editor. *Chemistry of the Solid State.* Butterworths Science Publishers, London, England. 1955. p. 184-233.

[5] *Ibid.*

[6] *Ibid.*, p. 299.

X-radiation we would get only very definite and quantized radiations from each element, and each transition would result in the particular wavelength radiation corresponding to the energy level difference of the shells. This, however, is not the case, and each element will emit a continuous spectrum of X rays. This is due to each impinging electron actually losing its energy in an unpredictable series of steps by successive impacts, rather than by a single impact.[7] [A more detailed explanation is omitted in this article.]

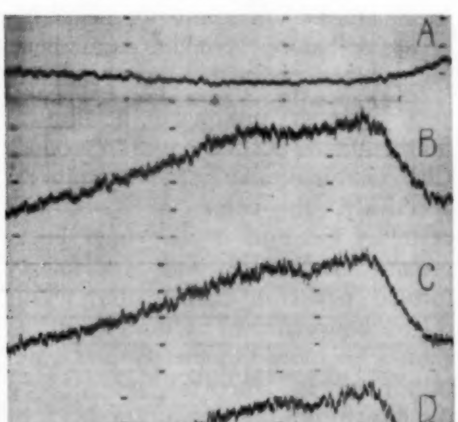
If the voltage across the electrodes of an X-ray tube is increased, we find definite maxima sharply appearing in the X-ray spectrum for each target element and rising higher above the continuous X-ray spectrum background as the voltage is further increased. These maxima form the characteristic X-ray line spectrum for an element

[7] Cullity. *Op. cit.*, p. 4.

FIGURE 3.

Diffraction pattern tests for residues of samples of nonahydrate heated from 260° to 700° C.

A. 260° C for 232 hours.
B. 560° C for 46 hours.
C. 560° C for 77 hours.
D. 560° C for 116 hours.
E. 700° C for 22 hours.
F. 700° C for 69 hours.



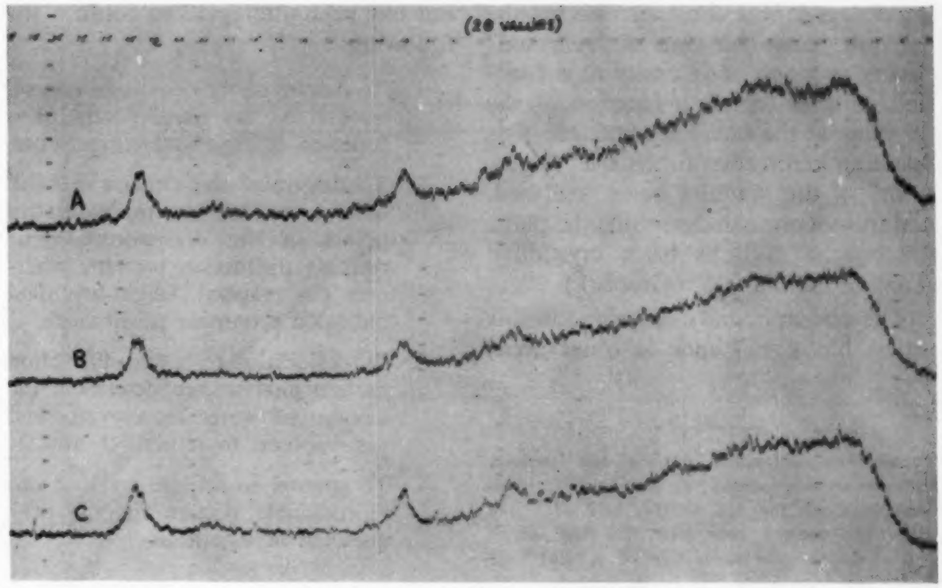


FIGURE 4.

Diffraction patterns from 5° to 76° C (2θ values), for samples heated at 700° and 800° C.

A. 700° C for 21.5 hours.
B. 700° C for 69 hours.
C. 800° C for 65 hours.

(Figure 1). They consist of lines called the K alpha, the K beta, L alpha, etc., depending upon their source.[8] Because of their relative intensities, in comparison to other lines emitted, the three most important to X-ray diffraction are the K-alpha one, the K-alpha two, and the K-beta one lines. By use of filters which allow the K-alpha radiation to pass, and are nearly opaque to the K-beta radiation, it is possible to get very nearly monochromatic radiation. (The wave length of the K-alpha one radiation for copper is 1.5405 Angstroms, and the filter is of nickel.) Since this radiation has a definite wave length and remains a constant, the only variation in a diffraction pattern for any material will have to be due to the plane spacings of atoms in crystalline structures being analyzed. In a relation originally formulated by W. L. Bragg, and now known as Bragg's Law, it was determined that:

$$n \lambda = 2d' \sin \theta$$

where λ is in the incident wave length, d' is the spacing between the scattering centers (in the case of a crystal, the distance between planes of atoms recurring in the crystal), and θ is the angle of incidence. The letter n is called the order of the diffraction and is always integral, since it represents the number of wave lengths in the total path difference. The waves involved will reinforce each other if they are just "in step" when they reach the detector; that is, if they are an integral number of wave lengths out of phase. If the path difference is only one wave length, reinforcement occurs, $n = 1$, and the phenomenon is called a first order "reflection." It is thus apparent that only at specific points and angles determined by the d' spacing of the planes of atoms will a given monochromatic incident beam reinforce another. Whether the specimen is a single crystal or a powder sample, we get a diffraction pattern which is unique for the material rendering the pattern.

The Diffractometer. The diffractometer is the standard device which directs this monochromatic X-ray beam (in this case from copper) into a powder specimen which is placed in a special holder in the target area of the diffractometer (Figure 2). The beams, which are favorably reinforced by their passage through the specimen, are picked up by a scintillation counter as it scans the region in which these beams emerge. These signals are passed to a scaling unit and amplification unit, which cause horizontal deflections of a pen so that the amplitude of the deflection is proportional to the intensity of the radiation being detected. Since the recording graph paper is mov-

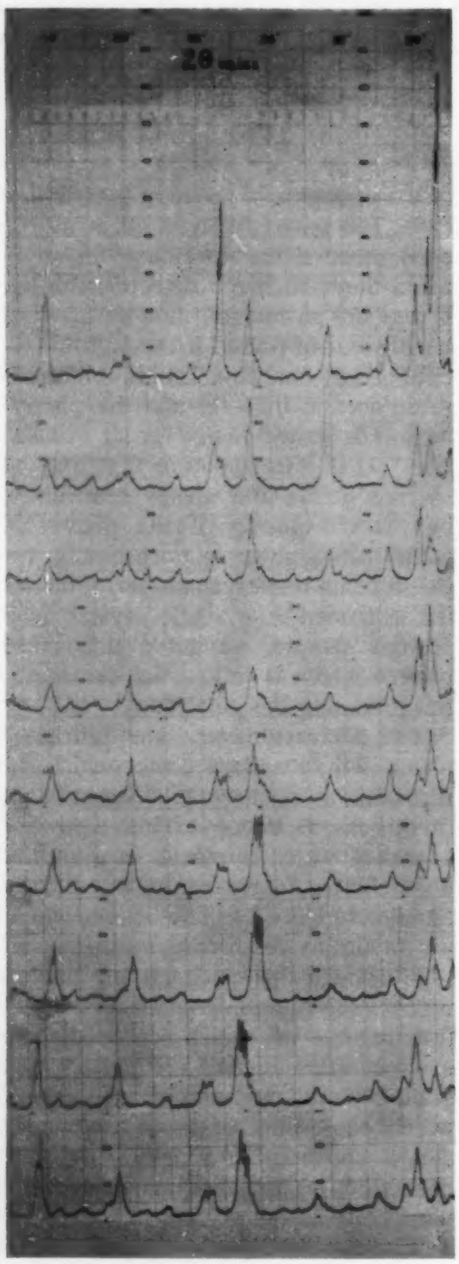
[8] Henry Semat. *Introduction to Atomic Physics*. Rinehart & Company, Inc., New York. 1946. p. 268.

ing forward at a constant rate, as the detector scans the area of "reflected" beams, a graph of intensity as a function of time (or as a function of the 2θ value at the time) is obtained. This resulting graph then forms the "fingerprint" of the material being analyzed, and from it one can determine the plane spacings as well as basic crystallitic shape of the material (Graph 1).

The research study described in this article has significance in other areas

FIGURE 5.

Nonahydrate diffraction pattern test sections. Patterns were repeated at half-hour intervals beginning with the top section, and each one below run one-half hour later. The last section was produced upon completion of a total front region run from 5° to 90° C (2θ values).



but has been attempted to confirm the following:

1. To determine the decomposition sequence of the nonahydrate as a function of time and temperature.
2. To determine the structural status of the residue at representative points in the decomposition by running diffraction patterns wherever the graphed weight-loss data indicated promising possibilities.
3. By desiccation tests and diffraction pattern analyses, to determine the amount of water loosely attached (as opposed to structural water).
4. To attempt to acquire a stable and reproducible pattern for the deliquescent nonahydrate.

The results of the decomposition weight-loss data may be noted in the graph on the following page. The small circles indicate the locations for diffraction pattern tests. Sample diffraction patterns, from completely amorphous material to that just beginning to show crystallite growth, may be noted in Figure 3, while the diffraction patterns in Figure 4 show definite peaks beginning to form, so that tentative identification of the residue becomes possible. Figure 5 shows a series of successive pattern runs for the nonahydrate itself (in which the humidity surrounding the sample was held as constant as possible), and the pattern shows clearly that if the sample has definite crystalline structure that sharp peaks at definite angles will result. It may also be noted that the peak locations seem to remain constant for the nonahydrate, but while it is adjusting to constant humidity conditions, the intensity of each peak varies greatly.

Though the major part of the information regarding experimentation cannot be included, the reader may find interesting the data accumulated on the decomposition sequence of the nonahydrate and the accompanying diffraction pattern information. The conclusions are:

1. Either a desiccant or very low temperature is able to remove the first three waters of hydration from the nonahydrate, producing the hexahydrate. The diffraction pattern indicates that the crystal lattice of the hexahydrate and the nonahydrate are fundamentally the same, since the *d'* spacings (indicated by peak locations) are repeated completely, while the peak intensities vary a great deal.

2. After the hexahydrate forms, the removal of additional water causes a breakdown in the nonahydrate-like structure, and the material becomes increasingly amorphous. The water removed here must therefore be structural water, rather than water loosely attached. (The nitrate groups apparently come off as nitric acid which is decomposed into water and nitrogen dioxide—a brown gas observed to be released at all higher temperatures.)

3. At no time, below 560° C, does any new crystalline structure emerge, and all patterns may be interpreted as mixture patterns gradually changing from the nonahydrate-like structure to totally amorphous material at 260° C. At this temperature, the weight-loss data shows precise correspondence with aluminum oxide monohydrate, while at 177° C the correspondence is with that of the trihydrate of aluminum oxide. This writer feels the data inconclusive as far as actually determining whether these are the monohydrates or trihydrates of Al_2O_3.

4. If the nonahydrate, or any decomposition product from the nonahydrate, is heated to 1000° C for a period of two hours or more, the material forms alpha aluminum oxide which becomes definitely crystalline as the heating process continues.

5. Though prolonged heating at 560, 700, and 800° C *seems* to produce Chi-, Gamma-, and Kappa-alumina respectively,[9] this cannot be stated with certainty because of the high background radiation and indefinitely formed peaks in each pattern. This region between 500° C and 1000° C should be more completely and carefully explored, since this seems to be the most promising region for study of decomposition products.

6. Without controlling the humidity surrounding the specimen *completely*, it is impossible to obtain a reproducible pattern for the nonahydrate. The peak locations remain constant, but the peak intensities are changed in very pronounced fashion by only slightly varying humidity, and thus change the amount of water present in the sample.

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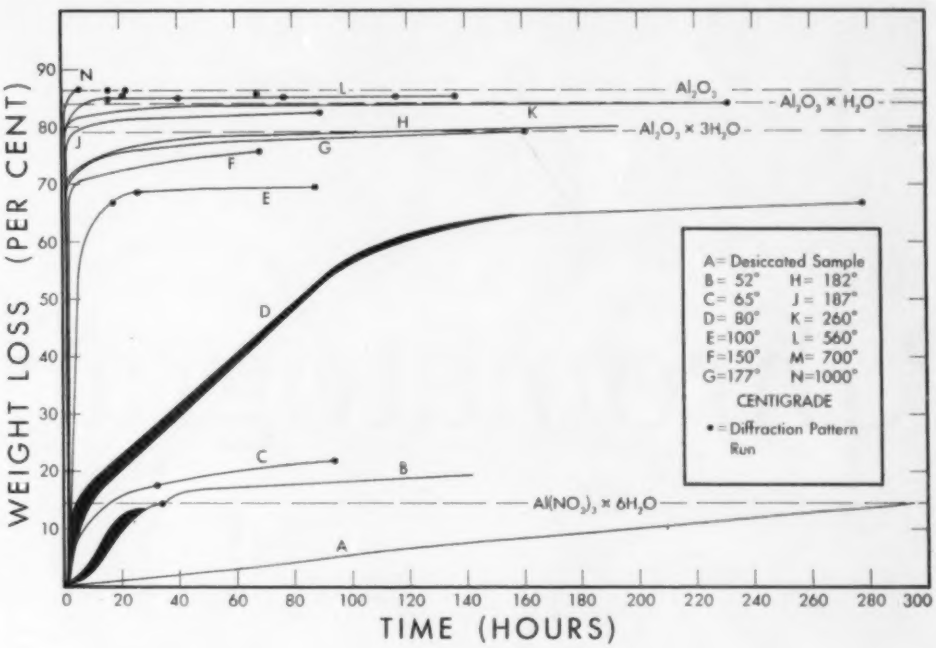
[9] H. C. Stumpf, *et al.* "Thermal Transformations of Aluminas and Alumina Hydrates." *Industrial & Engineering Chemistry*, 42:1398-1403. July 1950.

Summary of values received from research work. There is a rewarding sense of accomplishment and understanding that accompanies work with an instrument like the diffractometer. The relation between wave theory, diffraction phenomena, quantized energy levels in atoms, and inter-atomic distances in crystals becomes more clear and meaningful. Bragg's Law is no longer a symbolic statement in a text, but becomes a real and workable tool leading to a fundamental knowledge about the inner nature of matter. When one prepares a tiny sample of a material, places it inside the scatter-shield of the diffractometer, and then analyzes the peaks and valleys on a sheet of graph paper, a real appreciation for the *power* of such indirect reasoning processes is gained. These same formulas and ideas must be made real for all our students who continue in the field of science as it becomes ever more theoretical and symbolic. The feeling for the intimate relation between the symbolism of a formula, or mathematical statement, and the "realism" of nature, must be transmitted, and we cannot transmit with maximum efficiency that which we do not ourselves feel. We will at best teach *about* it.

What was learned regarding the question of specifically aiding students wishing to do research? *First,* unless the individual actually does the work and most of the thinking himself, he cannot get maximum benefit from such work. *Second,* the primary aid to be given to one just beginning experience in individual research is help in *finding* the information. *Third,* the student must be made completely aware of the necessity for absolute integrity in his work. We must encourage a sort of scientific skepticism regarding conclusions. Any conclusion founded on insufficient evidence is a disservice to the pursuit of knowledge.

Conclusions

This writer did not fully realize himself that the research person is really in a competitive field, subject to numerous pressures which could easily lead to publication of "conclusive" results which are at best "indicative" results. There is the necessity for maintaining a grant for a particular research project, a grant which may be partially dependent upon *favorable* results from the project work. There is the pressure



GRAPH 1.

of the desire to be "first" in the discovery of something new. There is the inevitable pressure to publish results. If a research scientist draws conclusions on the basis of insufficient evidence, regardless of pressures, he is no longer a scientist! If our students collect only "favorable" data they are learning anything but the methods of science. Science data must be developed with complete honesty above all else or knowledge is deterred rather than advanced.

If we can aid our students in finding information, in reporting *what they gain* and not *what they wish* they had gained, and if we can convey to them our honest belief that they have both the capability necessary for research and the responsibility to do their own work, we will have done our part. We will have added one new facet to their "opportunity" to learn. Isn't the provision of maximum "opportunity" for learning really our primary function in education? Each must learn for himself. We can only aid in the learning process.

Direction and encouragement, however, serve as important stimuli for student or teacher. Whether one is engaged in the classroom or in research, he should not overlook the use of these means to help others.

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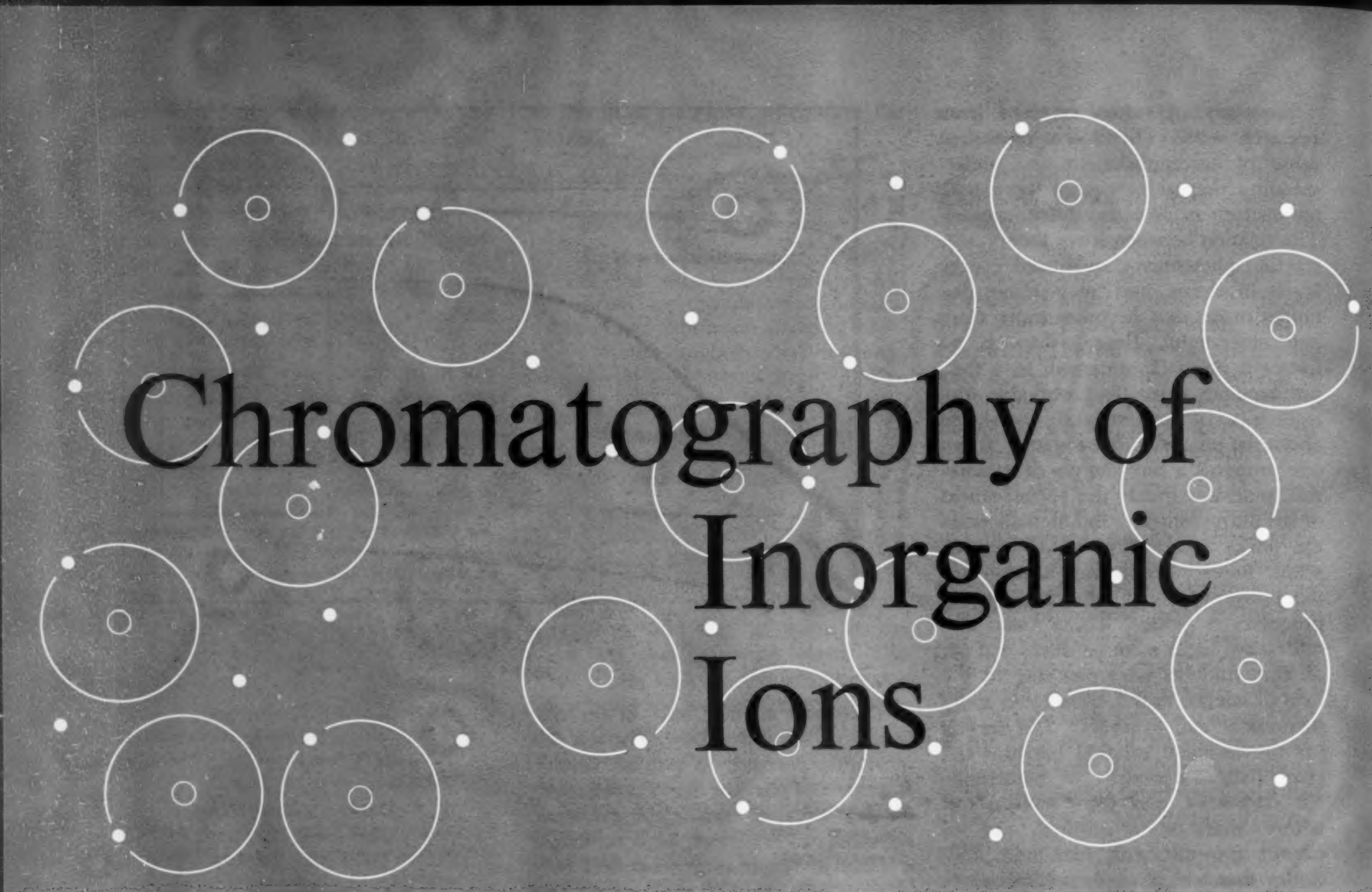


Chromatography of Inorganic Ions

By **ARNOLD E. BEREIT**

Chemistry Teacher, West Phoenix High School, Phoenix, Arizona

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

THE purpose of this article is to demonstrate the use of a simple chromatographic technique as a means of identifying the common inorganic ions. It is further intended to show that this method can simplify both the teaching and the development of techniques of qualitative analysis for the first-year high school chemistry student. It is also hoped that the use of this method will develop an interest for application in future investigations.

The new technique of chromatography (from *chroma* meaning color and *graph* meaning a writing) began around 1900 but it was the Russian botanist, Mikhael Tswett, who in 1903 found that leaf extracts dissolved in suitable solvents separated out into distinct bands of color when passed through a column of precipitated chalk.

Little was mentioned in the literature about this new technique until 1931 when Kahn and Lederer separated carotenes and xanthophylls, using columns of alumina and calcium carbonate. Since then the importance of Tswett's work was realized and new methods and techniques were developed.[1]

Paper chromatography was first described by Consden, Gordon, and Martin in 1944, and the use of paper chromatography in inorganic chemistry was introduced by M. Lederer and Linstead and collaborators in 1948.[2]

The method of circular paper chromatography as a tool of qualitative and quantitative analysis was developed by John G. Surak and Robert Martinovich in 1954.[3] This method is often referred to as the horizontal migration method.

EQUIPMENT (See Figure 1.)

1. Two Petri dishes the same diameter, using the two tops and two bottoms as one unit.
2. Filter paper—Whatman No. 1, 11.5 cm in diameter.
3. and 4. To save time in cutting the filter paper a pattern can be cut from a convenient piece of metal, using a razor blade (VI) and leaving about 1 cm from the center as a wick.
5. A capillary pipette can be substituted for the homemade pipette. It

[1] Edgar Lederer and Michael Lederer. *Chromatography—A Review of Principles and Applications.* Elsevier Publishing Company, New York. 1953.

[2] *Ibid.*

[3] J. G. Surak and R. Martinovich. "Circular Paper Chromatography in Qualitative Analysis." *Journal of Chemical Education*, 22:95. January 1955.

was found that the student can gain an insight into the usefulness of drawing glass by making his own pipette and obtaining a small enough opening to be used in this experiment.

6. Proportional divider for determining the R_{fc} factor.[4] (A) This piece of equipment is optional but again the student gains a greater understanding of the chromatography in determining an unknown by the use of the divider. (The R_{fc} factor is defined as the ratio of the distance from the initial spot to the ion to the distance from the initial spot to the edge of the solvent.)

PROCEDURE

1. Cut a wick about 1-cm long and .3-cm wide from center of the filter paper, in several pieces of 11.5-cm filter paper. Fold the wick at a 90° angle to the paper.
2. Using the pipette place one drop of the solution to be analyzed on the center of the filter paper directly on the edge of the fold for the wick.

[4] David F. Houston. "Proportional Divider for Rapid Determination of Chromatographic R_f Values." *Journal of Chemical Education*, 22:411. August 1955.

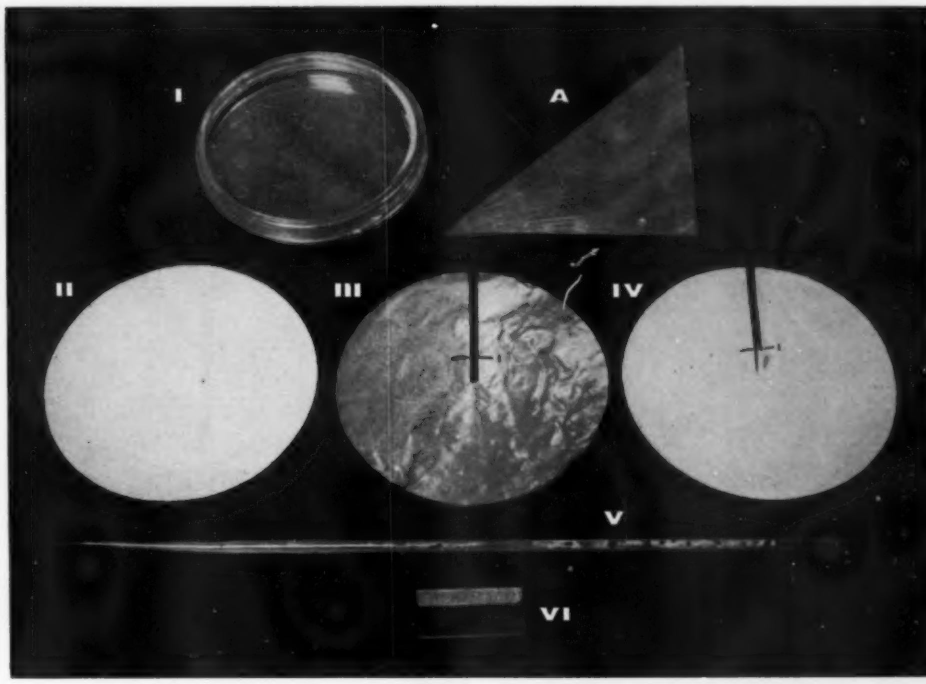
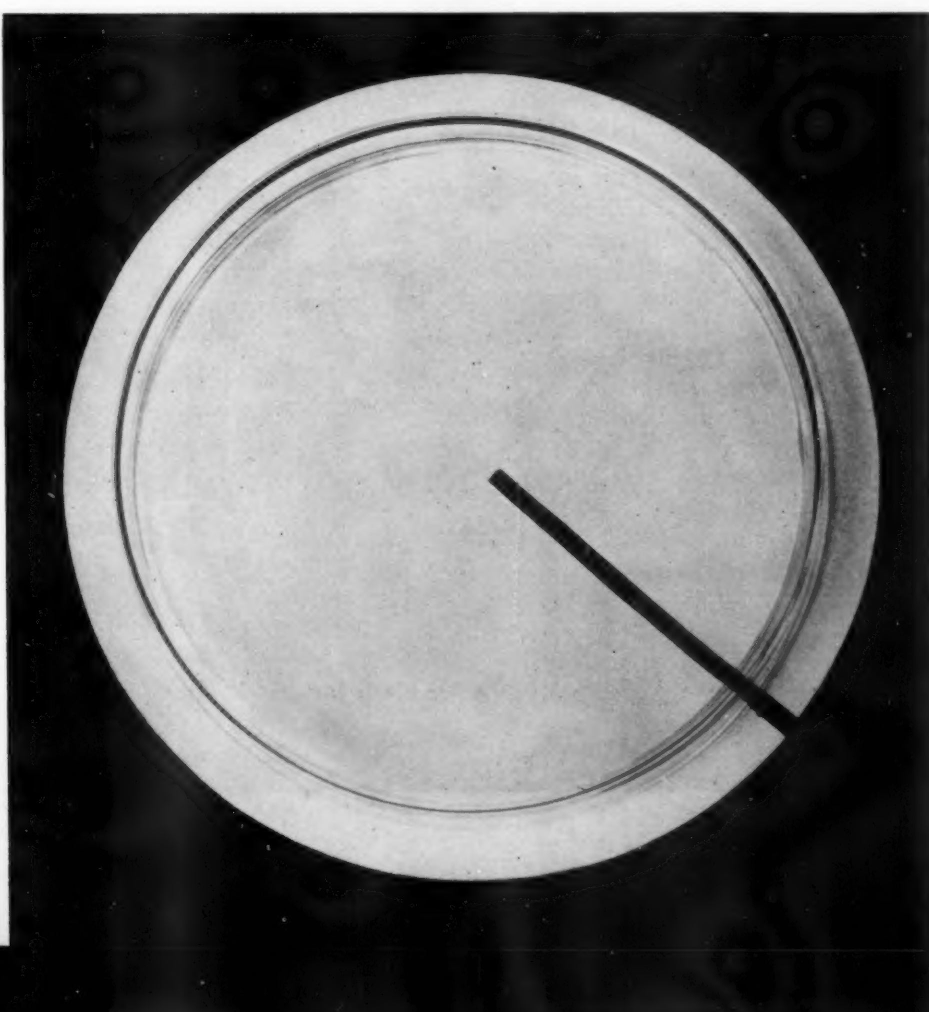


FIGURE 1.

3. Place about 10 ml of the developing solvent in a Petri dish and place the filter paper with the wick in the solution.
4. Place the equal-diameter half of the Petri dish on top and let developing take place for the required time. (See Figure 2.)
5. Remove filter paper, mark farthest point solvent has migrated, and let dry.
6. Identify ions present with corresponding identifying agent and by R_{fc} factor using divider.

FIGURE 2.



The cations can be separated into group by group reagents and then redissolved in solutions as nitrates or acetates of 5 per cent or less.[5] It is felt that for the regular high school student this is too time consuming in a regular laboratory period so the ions were given to students to be tested as a group.

Group I (Silver Group) Ag^+, Hg_2^{++}, Hg^{++}, Pb^{++}.

Group IIA (Copper Group) Pb^{++}, Cd^{++}, Cu^{++}, Bi^{+++}, Hg^{++}.

Group IIB (Arsenic Group) Sb^{+++}, As^{+++}, Sn^{++}.

Group IIIA (Aluminum Group) Al^{+++}, Zn^{++}.

Group IIIB (Iron Group) Ni^{++}, Mn^{++}, Cu^{++}, Fe^{+++}.

Group IV (Alkaline Earth Group) Sr^{++}, Ba^{++}, Ca^{++}.

Group V (Alkali Metals) K^+, Na^+, Li^+.

In a group each ion was developed separately and then as a group from 25-35 minutes using one Petri dish as

[5] A convenient method of obtaining groups. This was used by several advanced students as a special project. F. J. Welcher and Richard Hahn. *Semimicro Qualitative Analysis*. D. Van Nostrand Company, Inc., New York. 1957. p. 363, 412-29.

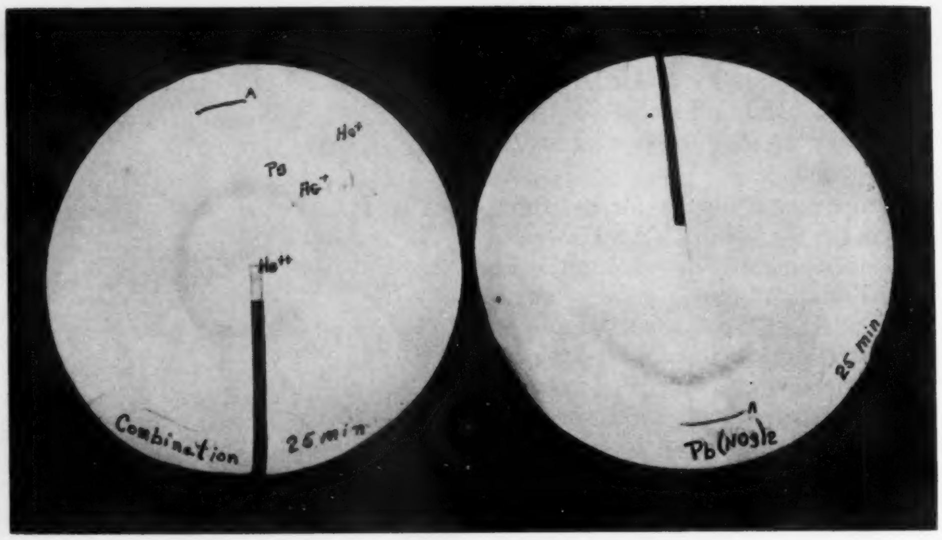


FIGURE 3.

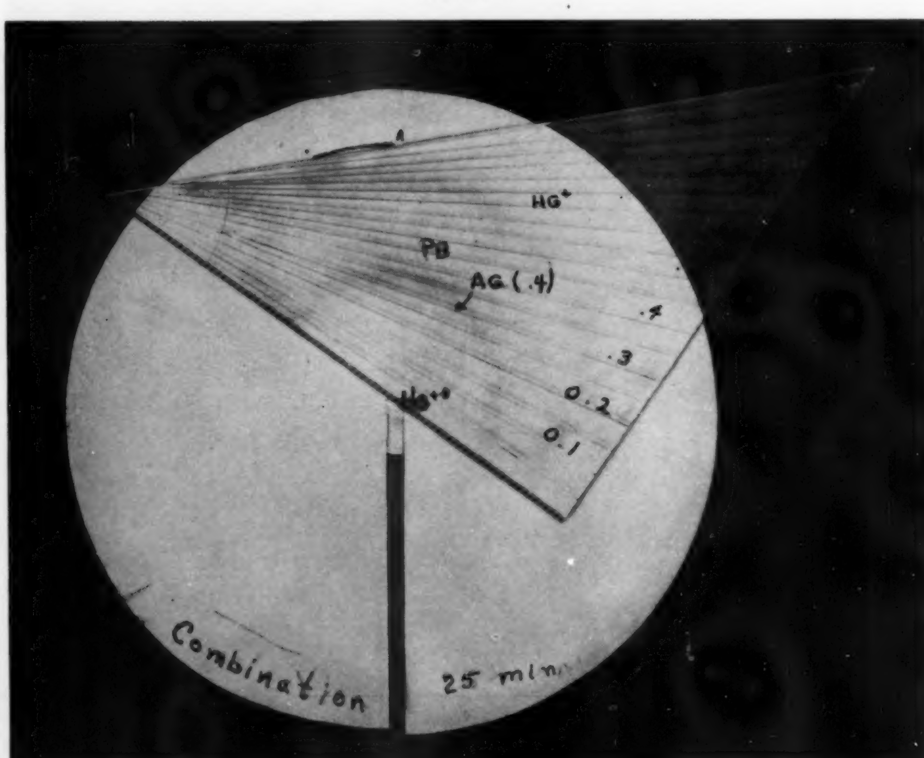
a control, with just the solvent in it before an unknown was given. The separate ion chromatographs can be held over the unknown (against a strong light) from a group as a help in identifying the unknown ion.

OBSERVATION

Figure 3 on the left shows the entire Group I as a chromatograph and on the right is the Pb ion. After developing, the ions can be identified by an identifying agent for each group. In the case of Group I, H_2S is used and produces the effect as shown in the figure.

As a further aid in identifying the ions the proportional divider is used to obtain the R_{fc} factor of each ion. (See Figure 4.) The base of the divider is placed at the impregnation point and the hypotenuse is placed tangent to the edge of the developing solution. The

FIGURE 4.



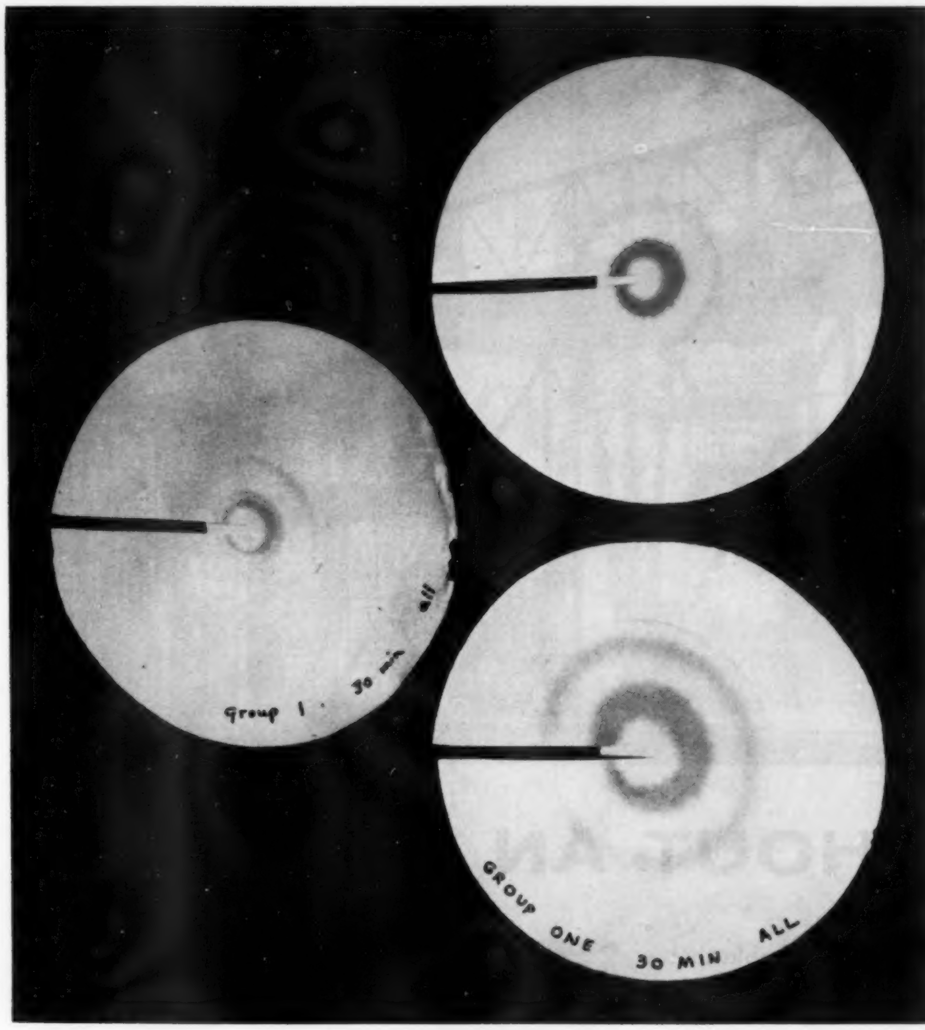


FIGURE 5.

R_{fc} value can be read to the nearest .01 at the edge of the ion-migration surface.

Below are listed the colors and R_{fc} values for Group I.[6]

Cation	Color	R_{fc}
Ag^{+}	Black	.30
Hg_2^{++}	Black	.00
Hg^{++}	Tan	.81
Pb^{++}	Brown	.45

DISCUSSION

The methods given for Group I are used in the other groups of cations. Each group has its own color and its own R_{fc} values.

Circular paper chromatography experiments in the second semester of high school chemistry have proven very valuable in stimulating interest in chromatography and also in introducing qualitative analysis. There are also many advantages to using this method in chemistry.

1. The short periods of time for developing a chromatograph lend themselves to the time allotted for the average high school laboratory period.
2. The methods and equipment used in these experiments are within the limits of understanding and capabilities of the beginning chemistry student (Figure 5 shows examples of the first chromatographs made by a high school student in second semester chemistry), but at the same time introduces them to techniques and methods that have practical application and are used today in various fields, such as isotope separation and identification and inorganic analysis.
3. All of the equipment and chemicals used can be obtained very readily and inexpensively. Such items of equipment as the pipette and divider can be made by the student.

[6] Surak and Martinovich. *Op. cit.*, p. 97.

ONE APPROACH TO SCIENCE SUPERVISION

By ALAN MANDELL

Science Supervisor, Norfolk County Public Schools, Norfolk, Virginia

THIS paper reports the progress of a program designed to strengthen and encourage science education in the public schools of Norfolk County, Virginia. The central idea of the program is the use of a team of *area science coordinators,* each responsible for active leadership in improving science education in all of the schools of his area.

Norfolk County composes some three hundred and fifty square miles of agricultural and industrial land with four dispersed residential sections. There are five high schools and twenty-three elementary schools, including five junior high schools. Approximately eight hundred teachers provide educational opportunities for about twenty-one thousand students.

The Area Coordinator Plan

Four master high school science teachers were selected to staff the team, one from each of the four residential areas. One member of the team was appointed to head up the entire program and the duties and responsibilities were outlined. Since this was to be an experimental program, specific procedures and methods were not established but left up to the resourcefulness of the coordinators. The team held monthly meetings for the exchange of ideas and progress reports. In addition there were many unplanned meetings coincident with school activities.

Services Provided by the Coordinators

In summarizing the year's activities it was found that the coordinators had been called upon to provide the services discussed below. The frequency and extent of these services were varied according to the needs and interests of the teachers of different areas.

1. *Elementary Science Education*—The area coordinators served as resource persons for the elementary teachers of their feeder schools. In this capacity they (1) provided or obtained materials and equipment and demonstrated its use to teachers, (2) worked with the teachers in developing unit plans or resource units, (3) provided demonstrations for elementary classes (often using high school students as assistants), and (4) aided the classroom teacher by encouragement and technical assistance.

2. *Junior High School Science Education*—All of the above services were also supplied to the science teachers in the junior high school program. In addition, they encouraged cooperation between junior high and senior high teachers by arranging group meetings and discussions. A series of nine workshops were conducted by the coordinators for the science teachers of the newly departmentalized seventh grade. These workshops were designed to give the teachers assistance with the subject-matter background and the techniques of teaching required for the new science curriculum for this grade.

3. *High School Science Education*—Each area coordinator taught three

classes in his own high school, assisted the sponsor of the science club, and worked with students in project activities.

4. *In-Service Education*—At several schools the coordinators were called upon to work with groups of teachers in grade-level, in-service training. These groups developed curriculum outlines or resource units pertinent to their grade levels. Through these activities the coordinators are developing the framework of a science curriculum for grades one through six. It is anticipated that summer workshops will provide an opportunity for elementary teachers and principals to evaluate and develop these curricular guides as useful teaching instruments during the school year.

5. *Science Open House Activity*—Each coordinator sponsored an elementary science open-house program at his high school for the feeder elementary and junior high schools. Individuals and classes displayed science projects they had worked on during the year. There was no competition between individuals or grades although prizes of participation were awarded to each school represented. Good press coverage and cooperation with Parent-Teacher Associations made the open house a center of community interest. It provided an opportunity for the community to see

Area science coordinator demonstrates the use of science equipment to fifth-grade teachers.

what is being done in science education at all grade levels.

Evaluation of the Area Coordinator Program

Results are summarized of the project at the end of the first year:

1. Aroused interest and activity in science education at all grade levels.

2. Development of elementary science education leadership in individual faculties. (Most of the schools worked with now have a member of the faculty as a science resource person. These are teachers who had ability and interest in this area and who now have the stimulus and support of the coordinator in exercising positive leadership with their own faculty.)

3. Achievement of greater quantitative (and perhaps more important,

Use of microprojector is explained by area coordinator to seventh-grade teachers.

NORFOLK COUNTY PUBLIC SCHOOLS, VA.

greater qualitative) use of the equipment and materials available to science education. (Many elementary teachers were either unaware of the materials available or uncertain as to their use.)

4. Stimulation of professional growth among elementary teachers. (Several teachers enrolled in an elementary science methods course offered in extension.)

5. Increased confidence on the part of seventh-grade science teachers following the special workshop series.

6. Provision of science experiences suitable for all levels of achievement at all grade levels.

7. Encouragement of student project activity and development of desirable attitudes and interests in science at early grade levels.

8. Identification of science talent and interest early in school program.

9. Professional growth of the coordinators themselves.

Some weaknesses in the program were also observed. The personalities of the coordinators are important to success of the program. The use of tact and an attitude of "How can I help you?" rather than "I have come to help you" was found to be very important in some cases. Not all teachers desired assistance while others desired too much. The need of a curriculum guide with scope and sequence became apparent, and it is anticipated that one will be developed as an outgrowth of the in-service training mentioned above.

Conclusion

The area coordinator plan as a method of science supervision for a school community has definite advantages and strengths. It utilizes the experience and talents of several individuals. It assures more opportunity for service to the many schools in larger systems. Local schools are working with a person they know in the community rather than someone from the "main office." The coordinator, as a high school teacher, learns firsthand about the background and experiences of his future students and identifies early some of his prospective talented science students. Teachers, students, and the coordinators can benefit from the program.

Support for continuance and expansion of the program in the coming school year is evidence of its acceptance as a successful project.

NORFOLK COUNTY PUBLIC SCHOOLS, VA.

Eighth-grade science class receives instructions from area science coordinator, A. B. Niemeyer.

Essentially, as in other activities, leadership is combined with teamwork. These two combinations produce results which are of ultimate benefit to the progress and development of any school program, large or small.

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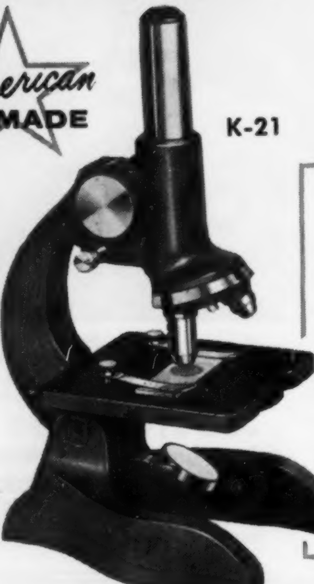

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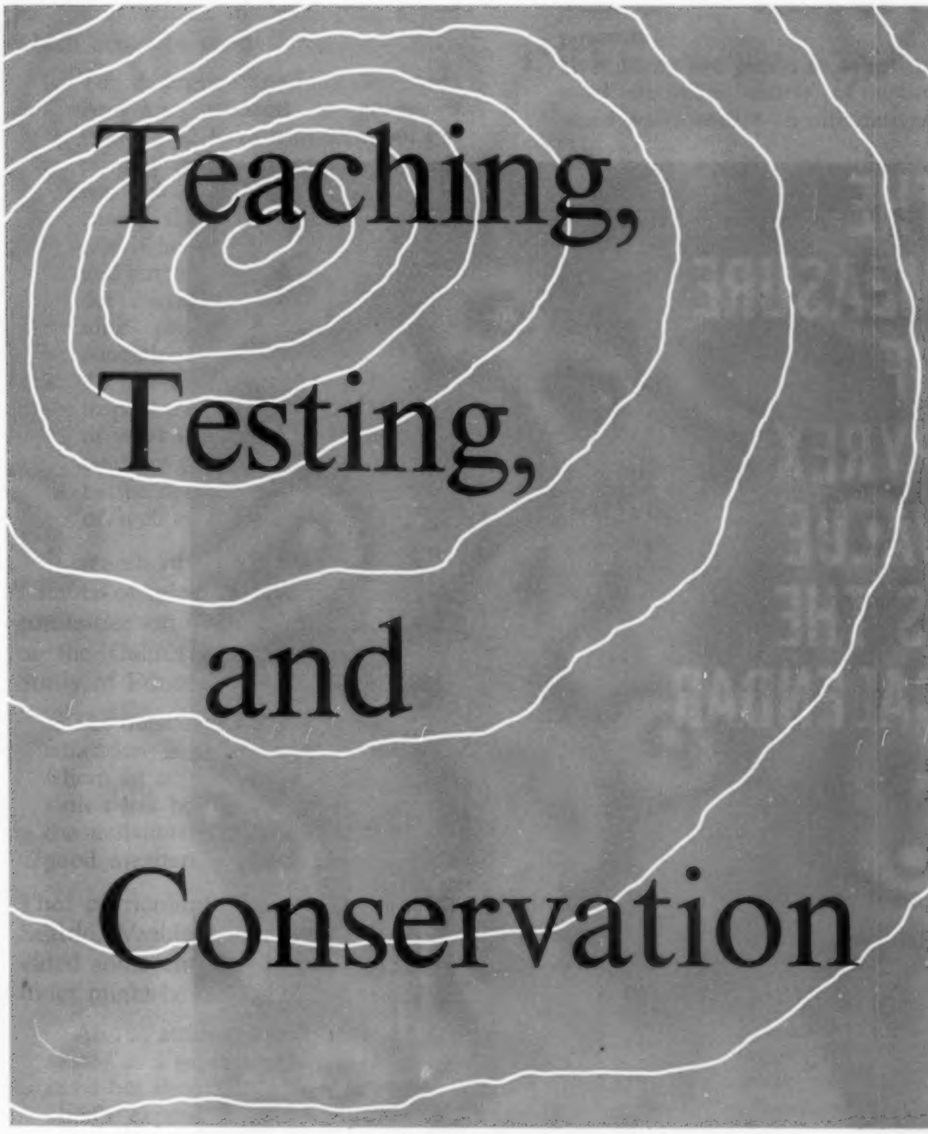

Teaching, Testing, and Conservation

By **SIDNEY L. BELT**

Science Section, Educational Testing Service, Princeton, New Jersey

Well-constructed objective tests should not be overlooked as a valuable source of ideas in curriculum planning and classroom teaching. The Conservation Foundation's recently developed "Test of Reasoning in Conservation" is one of these sources.

THE teacher, in the normal pursuit of his profession, is called upon to make many judgments of far-reaching effects on the educational progress of his students. Of particular significance are judgments regarding what objectives to work for, what content to use, and what methods to select. In making these judgments, the teacher is assisted by published aids, ranging from teaching outlines and lists of important concepts and understandings in a field, to complete sets of daily lesson plans. One source of ideas for curriculum development which should not be overlooked is the questions contained in well-constructed, published objective tests.

What features of well-constructed objective tests permit them to serve this function? For one thing, such tests probe those topics and outcomes which experts consider important. Teachers find it helpful to compare the professional judgment of the test authors with their own in arriving at decisions regarding objectives and content.

Secondly, a well-constructed test rewards the student who has real understanding rather than the one who is capable only of empty verbalization. Let us examine this difference in the light of the actual teaching situation by quoting the now classic story of William James:

> A friend of mine, visiting a school, was asking to examine a young class in geography. Glancing at the book she said: "Suppose you should dig a hole in the ground, hundreds of feet deep, how should you find it at the bottom—warmer or colder than on top?" None of the class replying, the teacher said: "I'm sure they know, but I think you didn't ask the question quite rightly. Let me try." So, taking the book, she asked: "In what condition is the interior of the globe?" and received the immediate answer from half the class at once: "The interior of the globe is in a condition of igneous fusion." [1]

The good objective test, by framing questions to probe true understanding, provides the teacher with models of how understanding can be cultivated in the classroom.

In the third place, a good published test covers a wide range of objectives. Educational objectives are often stated in terms so nebulous or ethereal that they more nearly represent pious hopes than realistic guideposts. The teacher, pressed for time, may be unable to relate such objectives to actual learning situations and may settle for mastery of information, trusting to luck that the relations to abstract goals will somehow be established. If the teacher can see that a particular outcome is measured in a test, however, he may be enabled to teach toward it directly.

The Test of Reasoning in Conservation

In order to illustrate more fully how good testing and good teaching are interrelated, let us consider the construction of a particular objective test in terms of both the specific purposes of the test and the particular nature of its subject-matter area. At the end of 1957, the Conservation Foundation called upon Educational Testing Serv-

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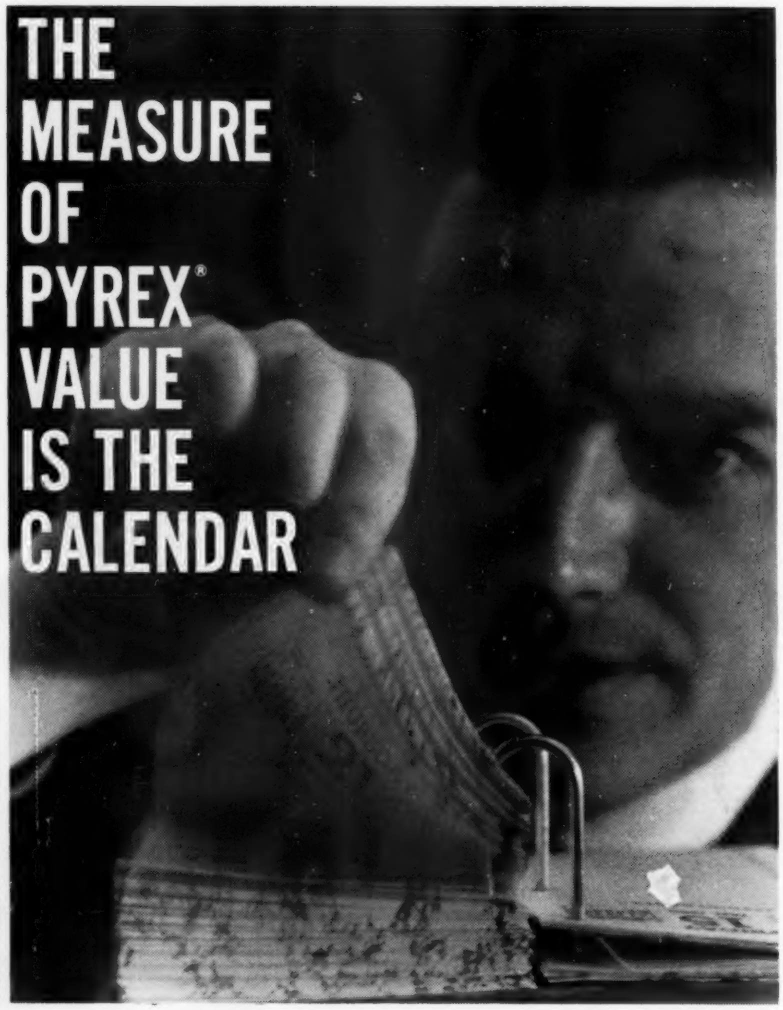
[1] William James. *Talks to Teachers on Psychology and to Students on Some of Life's Ideals.* Henry Holt and Company, Inc., New York. 1899. p. 150.



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ice for assistance in developing a test which could be used:

1. To determine periodically what American students in grades 9 through 12 have learned about important aspects of conservation. It was felt that such surveys would enable the Conservation Foundation, when called upon by teachers and curriculum committees, to render maximum assistance in planning programs of conservation education.
2. To provide classroom teachers who inspect the test with a clear picture of what specialists and experienced teachers of conservation believe to be the desired scope and objectives of such education.

A search of the literature yielded a number of relevant statements. A subcommittee on Conservation Education of the California Committee for the Study of Education had this to say:

> The outstanding aim of conservation education is to develop a people in whom an attitude and spirit of conservation has become as much a part of the individual personality as courtesy, good manners, honesty, and thrift.[2]

The curriculum department of the Seattle, Washington school system provided some clues as to how such attitudes might be related to behavior:

> An . . . attitude should never be presented as a generalization to be memorized but should be an outgrowth of a child's experience, study, and discussion—the result of inductive study of a situation. Real learning is that which is part of behavior. Our concern is not only with what children know—but how they feel. Facts are sterile things unless opinions and conclusions grow out of them; understandings and opinions are barren unless behavior is influenced.[3]

It was felt that the dual objective of the Conservation Foundation would be achieved by a test designed with these questions as guides:

1. What are the essential facts and concepts that are being learned by the pupils?
2. To what extent are pupils aware of the implications of these essential facts, concepts, and principles for themselves, for society, and for posterity?
3. How likely are pupils to select the most desirable course of action when confronted with alternatives?

Problem-Solving Sets

Since the last two questions are relatively more important than the first, the selection of types of test material to be utilized was in large part determined by their relative effectiveness in yielding valid answers to the last two questions. Problem-solving sets appeared to be one indicated testing technique. In these, either a brief description of a situation or graphic material involving a problem in conservation is presented. Test questions related to the material presented are then designed to: (1) test for an essential fact, concept, or principle; (2) probe the understanding of the implications of various facets of the problem; or (3) allow the pupil to indicate a preference for various solutions or courses of action. Emphasis is placed mainly on the latter two categories.

To determine whether or not a problem-solving set meets these specifications requires more than a cursory glance. Mere format conformity does not qualify a sequence of testing material as an appropriate problem-solving set. Indeed, in the final analysis, it is the skill and creativity of the question writer and not the item type *per se* which contributes to the effectiveness of the question. Consider the following two sequences which draw upon the same basic material.

Set A

Read the following paragraph carefully and answer questions 1-3.

In some communities sewage is dumped directly into streams where it is disposed of by bacterial actions and by the dissolved oxygen in the water slowly oxidizing it. However, fish and the higher plants of the stream die; and only a few bacteria and algae remain alive in the polluted stream. Other cities dispose of sewage by running it into closed sludge tanks and allowing bacteria to decompose it into nitrogen, methane, and a humus-like waste.

1. Sewage in streams is disposed of by
   (A) force of the running water
   (B) action of bacteria and algae
   (C) action of fish and higher plants
   *(D) oxidation and bacteria
2. The fish and higher plants soon die because
   *(A) they lack a supply of oxygen
   (B) they get too much nitrogen
   (C) the bacteria decay them
   (D) the algae reproduce too rapidly
3. Waste from sludge tanks
   (A) is used as lime
   *(B) is used as fertilizer
   (C) must be burned
   (D) must be buried

Set B

Read the following paragraph carefully and answer questions 4-6.

The sewage of city A is dumped directly into streams where it is disposed by bacterial action and by the dissolved oxygen in the water slowly oxidizing it. City B disposes of its sewage by running it into closed sludge tanks and allowing bacteria to decompose it into nitrogen, methane, and a humus-like waste.

4. The main advantage of disposing of sewage by dumping it directly into streams is that
   (A) it takes less time than using sludge tanks
   *(B) it saves the cost of sludge tanks
   (C) wastes are quickly removed from the vicinity of the city
   (D) harmful bacteria are quickly destroyed by sunlight and running water
5. Of the following, the main advantage of disposing of sewage by running it into closed sludge tanks is that
   (A) the waste from sludge tanks can be used for fertilizer
   (B) important minerals can be saved
   *(C) the open streams are kept safe for recreation
   (D) the sewage disposal plant provides gainful employment for a number of people
6. In comparing the methods used by cities A and B in disposing of their sewage one should realize that
   (A) both methods are equally good
   (B) both methods are equally bad
   (C) the method used by city A is better
   *(D) the method used by city B is better

Set B comes closer to qualifying as the desired type of problem-solving set than does Set A. Note that question 1 of Set A tests reading comprehension. Although question 2 tests an important conservation concept and question 3 an important fact of conservation, the

[2] *Guidebook for Conservation Education.* California Department of Natural Resources and Department of Education, Sacramento, California. 1950. p. 3.

[3] *Using Our Land Wisely—A Resource Unit for Intermediate Grades.* Seattle Public Schools, Curriculum Department, Board of Education, Seattle, Washington. 1948. p. 8-9.

* Denotes the correct answer.

pupil is not called upon to weigh implications or to select among courses of action. In set A we also observe that the options draw only upon purely scientific material, ignoring the impact of economic factors on conservation practices presented in Set B.

No. 4 of Set B, by presenting a practice undesirable for conservation without commenting on its undesirability, tacitly compels the student to weigh implications both biological and economic. Since the obvious answer for No. 5 (the effect of stream pollution on human health) is not listed, the student is required to weigh the alternatives presented and, by selecting from among these reasons, all valid, to reveal his scale of values pertaining to conservation. No. 6 calls on the student to make a value judgment as to courses of action. To be sure, No. 6 merely probes recognition of the desirable course of action and we have no assurance that the student would actually behave (e.g., in the voting booth) in accordance with the point of view expressed in his response. On the other hand, who would deny that recognition of correct courses of action is requisite to appropriate behavior?

The kind of reasoning which prompted the development of Set B instead of Set A is quite similar to the reasoning followed by the competent teacher in planning and carrying out his teaching. For example, teachers realize that presenting their students with a list of "do's and don'ts" does little to develop any growth in ability to make wise decisions. Teachers attempt to bring about this growth by exploring with their students the various factors that impinge upon a problem. They then arrange for the students to weigh the implications of the various courses of action. Only then do they call for a value judgment, if they feel that such a judgment is appropriate. By being involved in such a procedure, the student acquires a general appreciation that problems are often complex and that oversimplified answers can be misleading. In addition, the student acquires an arsenal of facts and concepts which are available for future use—available because they have been experienced in a meaningful context he can understand and appreciate.

Problem-solving sets, then, provide teachers with hints as to how specific topics might be placed in meaningful contexts. They also suggest a variety of contexts which might be used. Below is a set which suggests that topics discussed in the mass media might be exploited profitably.

The following letter appeared in a local Colorado newspaper:

Dear Editor:

In last Tuesday's editorial you showed how much control the government had by telling the businessman how to run his business. Well they sure stick their nose in my husband's business. My husband is a cattle rancher and he grazes several hundred head of sheep and cattle on a nearby national forest range. For this "privilege" he pays the government a monthly fee for each head. The government tells my husband every year how many head of cattle he will be allowed to graze on the national forest range that year. Not only that, but he has to keep his herds on the move. What I want to know is, what right has the government to tell my husband how many cattle we can have, especially when we pay for each head? And besides, what right has the

government to charge us for using nearby land that is not being used for anything else?

Yours truly,
A rancher's wife

1. Should the government have the right to charge ranchers for using the national forest range?
   *(A) Yes, because the national forest range belongs to all the people
   (B) Yes, because the government had to buy the land originally from private owners
   (C) No, because the national forest range should be free to all
   (D) No, because the national forest ranges have been established for the people living in the vicinity
2. Why is the rancher required to keep his cattle on the move?
   (A) To ensure that all the ranchers will have an equal share of the range
   (B) To prevent the spread of cattle disease
   *(C) To prevent the grass from being eaten too close to the ground
   (D) To improve the quality of the meat
3. Which of the following factors is most important in deciding how many animals should be allowed to graze each year?
   (A) The amount of livestock disease in the area
   (B) The present price of livestock and grain
   (C) The present availability of skilled help and the cost of transportation.
   *(D) The condition of the range forage plants

Here again we see the strategy which might be employed by a successful teacher in giving his students experience in interrelating facts and concepts. Note, for example, that the second question has to do essentially with "overgrazing." However, in order to answer the question correctly, real understanding is necessary. In contrast, the following question requires only that the pupil remember a verbal generalization.

Which one of the following is the most important principle of grassland conservation?
(A) Frequent burning of the grasslands
(B) Permitting only sheep to graze
*(C) Prevention of overgrazing
(D) Prevention of grazing of all kinds

Not all the questions in the *Test of Reasoning in Conservation* are parts of such sets. But all of the questions test aspects of the subject which are considered essential and which have important implications. The teacher would do well, therefore, to explore the ramifications of such individual questions as the following:

The United States, with less than 10 per cent of the world's population, uses approximately what per cent of the world's production of minerals ?
(A) Less than 10%
(B) Approximately 20%
*(C) Approximately 50%
(D) More than 90%

This question tests for knowledge of the fact that the United States plays a disproportionate part in depleting the world's mineral resources. A logical inference is that we may be moving in a direction that will place our industrial machine in jeopardy and that will hold

serious implications for our standard of living as well as for our survival in time of conflict, economic or military. Information of this nature, even though it might not be presently emphasized in the curriculum, can readily be incorporated by the alert teacher. These illustrations may shed light on some of the ways in which well-constructed tests can contribute to effective teaching.

But good tests not only provide guides for teachers, they also provide guides for learners. Students in general plan their work and adjust their study habits in accordance with the kind of tests they anticipate. If a teacher who strives for the development of understandings is forced to utilize measurement instruments which emphasize only memorization of facts, his students will soon come to study accordingly. In short, students tend to learn what tests tell them they are expected to learn. Tests which foster worthy objectives deserve our best efforts since their influence upon the entire learning process can be of such inestimable benefit.

A Cooperative Effort

The impression may prevail that a published objective test is the work of a single expert who thus imposes his own value judgments on classroom teachers. No doubt some tests are constructed in this way. However, successful test development undertakings are more often characterized by the collective effort of many people, including test specialists, classroom teachers, and students. The development of the Conservation Foundation's test illustrates this cooperative approach.

During the initial stages of the project, a number of informal meetings were held between members of the staffs of the Conservation Foundation and Educational Testing Service. These conferences resulted in a document which contained a statement of the purpose of the test, a tentative list of the "Basic Understandings and Concepts in Conservation," a subject-matter outline, and some sample test questions. The document served as the basic guide for ten classroom teachers, representing a wide geographical distribution, who wrote test questions. Test questions were reviewed and edited by staff members of Educational Testing Service and the Conservation Foundation and assembled into pretests. Each pretest was administered to at least 300 ninth and tenth graders. At the same time each pretest was being reviewed by at least twenty classroom teachers or other educators. From the teachers and conservation specialists, judgments were sought on the importance of the topics presented and on the effectiveness of the method of presentation. It was expected that performance would reveal ambiguities which might otherwise have gone undetected; that is, the review by teachers and specialists was to pass judgment on the significance of the *content*, whereas the tryout on the students was to pass judgment on the *communication* aspects of the questions.

On the basis of pretesting and reviews, questions were again revised and assembled into three 40-minute final forms. Each final form was again reviewed by some twenty classroom teachers and conservation educators. These final forms were made available on a limited experimental basis during the 1959-60 school year. Published forms will profit from these tryouts. From inception to conclusion the project has required almost three years.

Classroom IDEAS

Biology

Cyclosis and Plasmolysis

By FRANK E. WOLF, State Teachers College, Fitchburg, Massachusetts

Materials: Student microscope, Elodea growing in strong light, hypertonic sodium chloride solution.

Procedure: 1. Place a young Elodea leaf on a slide in a drop of water, cover with a cover glass. If the plant has been in strong light for several hours, cyclosis may be observed. Under high power the protoplasmic movement will be seen to cause the movement of the chloroplasts.

2. Withdraw the water from the preparation, using a paper towel or pocket tissue. Introduce a drop of the hypertonic saline solution. After a short period, observe the leaf toward the end away from the growing tip. Notice the shrinking of the cell membrane away from the cell wall. The protoplasm will condense toward the center of the boundary of the cell wall. Salt solution will occupy the space between the cell wall and cell membrane.

Discussion: Elodea is easily kept in a school aquarium and is a very useful

plant, not only for this demonstration, but in demonstrating photosynthesis and for collecting oxygen. It is possible to arrange this demonstration as an experiment. The problem to be solved would be: how may we determine that saline solution does, in fact, occupy the space between the cell wall and cell membrane? To answer the problem, allow the saline preparation to dry, and demonstrate salt crystals in the space in question, using a polariscope.

Chemistry

Quantitative Analysis

By RICHARD B. KENT, Foothill College, Mt. View, California

The following investigation was done during the summer of 1959, under the supervision of Dr. D. A. Skoog of Stanford University, and we believe that the following experiment should provide high school students with familiarity in some analytical procedures.

The conversion of barium-chloride-dihydrate to barium sulfate was picked for this experiment because of the low solubility of barium sulfate plus the high degree of accuracy obtained in a gravimetric determination.

Nature of Experiment

To determine the empirical formula for the stable hydrate of $BaCl_2$.

To determine the percentage conversion of hydrated $BaCl_2$ to $BaSO_4$ by means of equations:

$$BaCl_2 \cdot 2H_2O \xrightarrow{\Delta h} BaCl_2 + 2H_2O$$
$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2H^+ + 2Cl^-$$

Materials Needed

1. Chemicals—distilled water, C.P. reagent HCl, C.P. reagent H_2SO_4, and C.P. reagent $BaCl_2 \cdot 2H_2O$.

2. Equipment—weighing bottle, desiccator, spatula, analytical balance, drying oven (range 110-150°C) or air bath with burner, 400-ml beaker with 10-cm watch glass, glass stirring rod, graduated cylinder, medicine dropper, pipette or burette tube (volume 10-25 ml), hot plate, funnel (60°), ashless filter paper, crucible and lid, Bunsen or Tirrell burner, ring stand with ring, clay triangle, wash bottle, and indicator paper.

Procedure

Five per cent (5 ml H_2SO_4/100 ml of solution) and 0.5 per cent (0.5 ml H_2SO_4/100 ml of solution) solutions of sulfuric acid may be made up in advance by the instructor or students. A sufficient number of marked weighing bottles may also be cleaned and dried in advance and stored in a desiccator.

Students should obtain a weighing bottle and weigh it on the analytical balance to the nearest 0.1 mg. Following this, a small (0.5-1.0 g) sample of hydrated barium chloride is weighed into bottle to the nearest 0.1 mg and the sample containing bottle is then dried in an oven (110-150°C) for a period of one to two hours or over air bath for 30 minutes. Following this the bottle is allowed to cool to room temperature, within a desiccator, and again weighed to the nearest 0.1 mg. (Note: The loss of weight observed should be due entirely to the water of hydration since barium chloride does not decompose at temperatures involved here.)

The dried and weighed sample is then quantitatively transferred to a 400-ml beaker using approximately 100 ml of distilled H_2O to effect the transfer. One ml of concentrated HCl is added and then the solution is brought to a boil. (Note: Avoid spattering due to too rapid boiling.) Approximately 10 ml of hot, 5 per cent H_2SO_4 is slowly added to solution by means of a pipette or burette tube, stirring constantly. Precipitation of $BaSO_4$ will be noted at this time. Completeness of reaction can be tested by allowing beaker's contents to settle and adding one more drop of acid. If reaction is not complete, more precipitation will be noted.

Assuming reaction is complete, the beaker, covered with a watch glass, should be placed on a hot plate or steam bath and the precipitate allowed to digest for an hour or so. (Note: Avoid any vigorous boiling during the digestion period.)

A marked crucible, previously heated for 15-20 minutes with Bunsen burner and allowed to cool within desiccator, is weighed to the nearest 0.1 mg and returned to desiccator until needed.

A long-stemmed, 60°-angle funnel is prepared for filtration using ashless fil-

NOTE: The author completed eight years with the high school in Sandusky, Ohio, before changing to the present location. The study presented here was begun under a research grant from the National Institutes of Health in 1958.

ter paper, and the supernatant from the beaker is decanted off through the filter paper. The precipitate is quantitatively transferred to the filter paper, using a hot 0.5 per cent solution of H_2SO_4 for transfer and keeping transfer volume to a minimum. The precipitate is washed twice with small volumes of hot distilled water to remove all traces of acid ion. (Note: May be checked with litmus or hydrion paper.) Final volume of filtrate and water should not exceed 200 ml.

Filter paper is carefully removed from funnel, folded, and placed in the previously weighed crucible. The paper is then very carefully charred off with use of burner flame beneath crucible. (Note: Avoid combustion within crucible.) All remaining carbon is oxidized and the precipitate is then heated for 30 minutes within the crucible, with the crucible bottom attaining a cherry red glow at this time if the burner flame is properly adjusted. The crucible is then allowed to come to room temperature, within a desiccator, and weighed to the nearest 0.1 mg.

Calculations

1. Data necessary for determination:
   - a. Weight of dry, empty weighing bottle ________g
   - b. Weight of bottle plus hydrate ________g
   - c. Weight of bottle plus anhydrous salt ________g
   - d. Weight of ignited crucible ________g
   - e. Weight of crucible plus dried $BaSO_4$ ________g
   - f. b minus a = weight of hydrated salt ________g
   - g. c minus a = weight of anhydrous salt ________g
   - h. b minus c = weight of water of hydration ________g
   - i. e minus d = weight of barium sulfate ________g

2. To calculate empirical formula of the compound:
   - a. Weight of Ba^{++} in sample = weight of barium sulfate (i) $\times \frac{\text{formula wt. of Ba}}{\text{formula wt. } BaSO_4}$
   - b. Weight of H_2O in sample = weight obtained in 1-(h)
   - c. Weight of Cl^- in sample = (f) minus (h) minus (2-a) (Hydrated salt's weight minus water of hydration minus weight of Ba^{++})
   - d. Find gram-atoms of each component in compound
     - (1) gram-atoms of water $= \frac{(h)}{18}$
     - (2) gram-atoms of $Ba^{++} = \frac{(2\text{-a})}{137}$
     - (3) gram-atoms of $Cl^- = \frac{(2\text{-c})}{35.5}$
   - e. Now x, y, and z in $Ba_xCl_y \cdot z(H_2O)$ can be evaluated by dividing each of the number of gram-atoms by the smallest of these.

3. To determine percentage conversion of barium chloride to barium sulfate:
   - a. Weight of dried, ignited $BaSO_4$ obtained (1-i) ________g
   - b. Weight of $BaSO_4$ that should have been obtained ________g $\frac{\text{formula wt. } BaCl_2 \text{ hydrate}}{\text{formula wt. } BASO_4}$ $\times$ weight $BaCL_2$ hydrate started with (1-f)
   - c. 3-a divided by 3-b gives percentage conversion ________g

Conclusions

With reasonable care on the part of the student, he should be able to get good reproducible results and end up with an experimental determination of the empirical formula for the hydrated barium chloride crystal as well as a high percentage conversion of this hydrate to the insoluble $BaSO_4$.

Remarks

Using the above procedure and apparatus, the author was able, over the course of many such determinations, to obtain an average value of 14.68 per cent for the water of hydration with an average deviation of 0.04 per cent thus leading to the correct empirical formula of $BaCl_2 \cdot 2H_2O$. An average yield of 99.67 per cent with an average deviation of 0.24 per cent was obtained for the conversion of the hydrated barium chloride to barium sulfate.

We feel that an experiment, such as the one outlined above, might be of considerable value in the high school program when placed in its proper perspective. An attempt to evaluate this might include some of the following points:

1. There is a need, on the high school level at least, for the better student to be introduced to some of the quantitative aspects of chemistry. One of the greatest problems encountered in the high school laboratory is the relatively short working time in an allotted laboratory period. For this reason, we have attempted to break this experiment up into several one-hour sessions, so that interested teachers might know how to plan their laboratory sessions. The experiment has been allotted a total of five hours with the thought that a group, working approximately one hour per day, might complete it in one week's time. The schedule is as follows:

First hour. Student cleans and dries his crucible, then places it in a desiccator until needed. He obtains a previously cleaned and dried weighing bottle from instructor and weighs it on the analytical balance. The sample may then be measured into his bottle and the new weight recorded. Sample is then placed in drying oven or on air bath and removed at the appropriate time by the student or the instructor, and placed in the desiccator until the following laboratory period.

Second hour. Cooled and dried sample is weighed again so that loss of water may be calculated, transferred to a beaker, dissolved in water, brought to a slow boil, and precipitated with previously prepared, hot 5 per cent H_2SO_4. The beaker is then placed on a hot plate and allowed for the appropriate time

to digest, and then again removed by the student or instructor and allowed to cool.

Third hour. The student sets up his filtration apparatus, prepares his hot wash water and 0.5 per cent H_2SO_4, transfers his precipitate quantitatively, washes it, and readies the filter paper for charring and ignition. The paper can be stored in a covered crucible until the next hour.

Fourth hour. The student chars off the filter paper and ignites the precipitate for at least 30 minutes. He then places the crucible in a desiccator to cool until the next hour.

Fifth hour. The student weighs the precipitate in the crucible and then makes his calculations.

2. Assuming that the high school chemistry laboratory has access to an analytical balance, this experiment would give the student a chance to either gain or demonstrate proficiency in the use of this balance, rather than merely being introduced to it with the statement that "Here is a tool used by chemists for accurate weighings, if they desire such."

3. The student's results, in such an experiment, regardless of his accuracy, should leave him with an appreciation for the detailed work necessary in a quantitative analysis.

4. The student actually *uses* methods for determining the empirical formula of a compound. Too often, this is done on a theoretical basis, in the classroom, with no actual physical processes involved and the student has no chance to correlate what he has learned with what he actually does in the laboratory.

5. If the student does enough individual determinations, he gains an appreciation for the precision of his work and factors which may affect this precision.

6. There are many procedures involved in this experiment, e.g., quantitative transfer of a precipitate, ignition of a filter paper, digestion of a precipitate, etc., which will force the student to use reference books, and thus gain insight into new laboratory techniques.

BSCS

The BIOLOGICAL SCIENCES CURRICULUM STUDY...

Its Organization, Plans, and Progress

THE Biological Sciences Curriculum Study, an educational project of the American Institute of Biological Sciences with major support from the National Science Foundation, had its origin in the conviction of many biologists in the United States that scientific curricula at all levels of instruction should be reviewed in the light of recent technical and scientific advances. When seen in broad perspective, it is obvious that there is an extremely wide range in the content and quality of biology offerings in our secondary schools and colleges. The amount and kind of teacher training, presentation of materials, physical facilities, and the role of biology in the total curriculum are all known to vary tremendously and it is no secret that much could be improved.

Biology has a real contribution to make to an understanding of society and to the expected direction of its evolution. But its role is not always well understood. It is important that every literate person understand what biology is. As a basic science it is an integral part of our present scientific revolution. It is not entirely medicine or agriculture. Though drawing upon chemistry and physics, it deals with more complex structures and organizations, and its level of major generalization is less well formulated and precise.

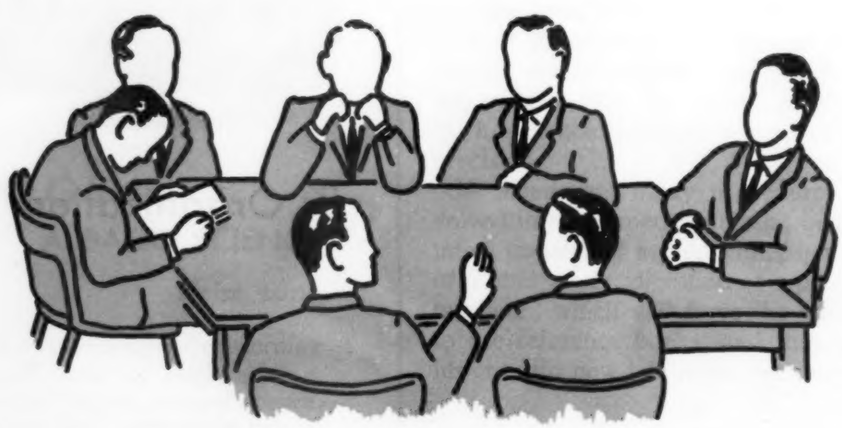
For most American secondary school students biology is the only science course that is taken. It is thus especially important that through biology the general student learns to appreciate the growth of scientific knowledge and acquires a conception of the basis of scientific thought. It is important that he has an understanding of his own place in the scheme of nature, and that as a living organism he has much in common with all other living things. He should develop an intellectual and esthetic appreciation of the beauty, drama, and tragedy of the living world, and an understanding of the biological basis of many of the problems and procedures in medicine, public health, and conservation.

Against and because of this background, the Biological Sciences Curriculum Study has the responsibility of developing an improved sequence of life science subjects in the schools and colleges; to make recommendations for the content of courses; to suggest effective methods of presenting these materials; to recommend appropriate placement of biology topics with respect to other courses in the curriculum; to explore special courses for exceptional students; and to design materials for both in- and pre-service teachers of biological sciences.

Plans for such an educational program in biology were developed over a three-year period by the AIBS Education Committee under the chairmanship of Dr. Oswald Tippo of the Yale University (New Haven, Connecticut) Department of Botany. All possible occasions were utilized to appraise biologists of these plans and to elicit suggestions from them. By January 1959, plans were sufficiently advanced so that the Biological Sciences Curriculum Study could be established. The program is being administered by a small staff with headquarters at the University of Colorado in Boulder.

It is planned that the BSCS will eventually be involved in biological education at all levels. It was early recommended that the high school course be considered first, since this level is thought to be the most crucial one at the present time. It is anticipated that at a later date the Study will investigate elementary and college levels. Studies are also contemplated of improvements that could be made in biological education for the general public and some of its special groups. Because of the speed with which the sciences are changing modern life, biological education cannot simply be limited to students enrolled in schools. Moreover, many aspects of biological education are not restricted to classroom situations and supplementation is necessary. Investigations will thus be concerned with the potentialities in adult education, periodicals, books, newspapers, films, television, radio, museums, zoological gardens, National and State Parks, and various youth programs such as the Boy and Girl Scouts of America. The entire program, from the initial phases of information gathering, through analysis, testing, and final recommendations, should take several years.

The Committees and Their Responsibilities



The general policy of the BSCS is determined by a Steering Committee composed of twenty-seven members currently representing the following categories: professors of biology, high school biology teachers, science supervisors, science educators, medical and agricultural educators, and university administrators. The chairman is Dr. Bentley Glass of Johns Hopkins University in Maryland. At the present time the largest single group on the Steering Committee consists of professional biologists, for it is felt that the design of a new curriculum in biology

should depend heavily upon those individuals who have an intensive knowledge of the various facets of the field of biology. Men working on the frontiers of the science have such a knowledge. It is intended that a greater proportion of in-service secondary school biology teachers will be recruited as the Study becomes more deeply involved in the production and implementation of curricular materials.

Dr. John A. Moore, Columbia University, New York City, is chairman of the Committee on Course Content which is designing a first course in biology for the secondary school level, since this is considered to be the pivotal area in American education today. It will also be important to determine whether additional courses, perhaps in the twelfth grade, are desirable for superior students, college preparatory students, and those with a special interest in biology as a career. A careful investigation of the biological content in junior high school general science courses will also be made.

It is important that this committee develop a course in which the nature of scientific inquiry, the intellectual history of biological concepts, genetic continuity, regulation, complementary structure and function, diversity, and many other similar important concepts are made clear to the student. Certain concepts dealing with the nature of science such as the quantitative approach, incertitude, esthetics, limits of knowledge, speculation, temporal parameters, dynamic systems, multiple variables, and others should form a woof throughout the fabric of the entire course, being presented again and again in a multiplicity of examples to emphasize their pervading nature.

The wealth of biological knowledge is obviously so extensive that the committee can select only a fraction for presentation in a year's course. The selection itself will be made with the full realization that only a few students will become biologists. For the majority the high school course in biology is a terminal experience in this field, and represents the only opportunity for the student to become conversantly familiar with an important facet of man's intellectual efforts. For a few, the course should also reveal the vocational possibilities for careers.

Because the BSCS Steering Committee feels that much current laboratory instruction in biology is less than inspiring, a Committee on Innovations in Laboratory Instruction has been organized. Dr. Addison E. Lee, University of Texas, Austin, is the chairman. In cooperation with a number of high school and college teachers this committee is evaluating the role of laboratory experience in high school biology and it is intended that two improved series of exercises will be produced. The committee is devoting most of its time to an experimental laboratory program in which approximately one dozen laboratory units, or blocks, are being developed. Each "block" is composed of a comprehensive unit of laboratory and field work which is complete in itself. A single unit, or block, will probably take the entire class a period of five or six weeks to finish. Each block will deal with the investigation of biological problems related to a particular area in considerable depth.

The relation of these laboratory blocks to the remainder of the course is very important. The committee is aware of the problems of time and available space in the average American high school. The block of thirty hours laboratory work plus thirty outside assignment hours will fit the available time during a six-week period of five class hours per week. To do this it must constitute the regular class work during that portion of the year. A single group of students would usually not take more than one block a year. This represents a valuable contribution to the science student and future citizen alike. Through an organized series of related laboratory experiences, in which there is real participation in scientific investigation, the individual develops an understanding of the nature of the scientific method and spirit. Such a fundamental objective could well monopolize the time of the course for one-sixth of the year. For those school systems in which, for a number of reasons, the block program is at present unsuitable, a separate subcommittee will produce an improved series of more conventional exercises and demonstrations.

There is a serious need for special programs for gifted and talented students and a special committee has been established for this purpose, with Dr. Paul F. Brandwein of Harcourt, Brace and Company, Inc., New York City as its chairman.

Of prime importance in any teaching activity is the teacher. A highly qualified and representative group of people has been recruited to serve as a Committee on Teacher Preparation. Dr. Joseph J. Schwab, University of Chicago, Illinois, is the chairman. The members of this committee are well aware that the high school teacher, who needs to be a generalist and an interpreter of science, is usually taught in biology by men who are specialists and investigators. It is obviously important that the high school teacher understand the ways in which biologists accumulate knowledge of their science. Teachers should be appreciative and informed concerning the nature of the scientific enterprise. Unfortunately, this experience is typically gained only at the Ph.D. level. Provision is not normally made for such training at lower levels of instruction. Furthermore, few recommendations for alleviating this condition have been made. Most recommendations for teacher training in biology have been based on surveys of existing practices, with the result that one seldom finds such innovations in teacher education. Courses that satisfy certification requirements are frequently of little benefit to pre- or in-service teachers. Though courses such as the history and philosophy of science would be very valuable in improving the climate of high school science courses, they are not required for certification in any state.

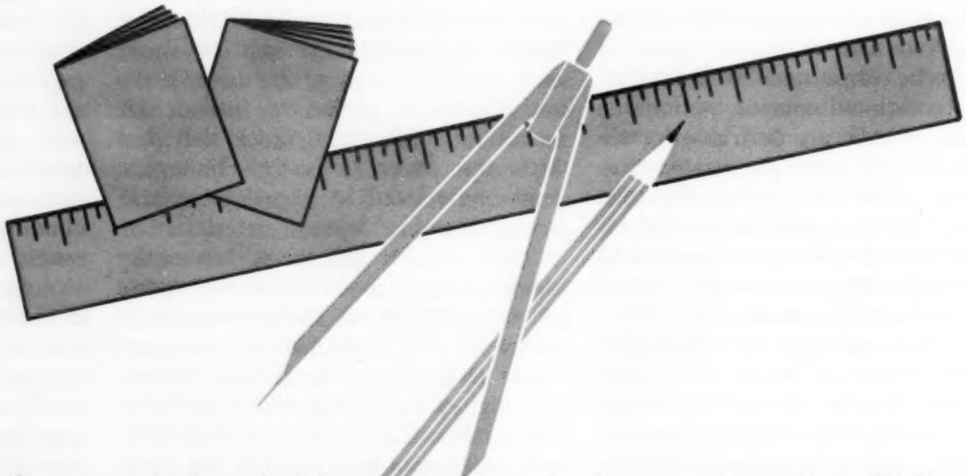
Much of the criticism levied against the teaching of science today is related to the difficulty of encompassing the entire range of subject matter included in the field of biology. Redesign of existing in-service and pre-service courses is certainly part of the answer. Perhaps even more important, however, scientists must learn how to communicate their findings to teachers in understandable language, and to make these ideas available through less technical publications than are now available. To help satisfy this need the BSCS is considering the production of an extensive pamphlet series. We need a teacher-training program designed to accomplish the purposes for which biology courses should be taught—to turn out teachers with an understanding of science and of children.

A Committee on Publications under the chairmanship of Dr. Hiden T. Cox, AIBS, will supervise the publication of materials produced by the BSCS.

Consultants on Current Projects

Consultants for the Biological Sciences Curriculum Study are presently engaged in two separate programs. A number of high school biology teachers are generally recognized in their communities as being exceptionally effective. One program is concerned with the assembly and analysis of case histories and performances of a representative group of these teachers with suitable controls. The consultant in this project is Dr. C. Francis Byers, formerly Assistant Dean of the College of Arts and Sciences at the University of Florida and now at Lewis-Clark Normal School in Idaho. The other program is the preparation of a digest of the vast literature on education in biological sciences for the immediate use of BSCS committee members and consultants. It is planned to prepare a volume on biological education in the United States. This work is being done by Dr. Paul DeH. Hurd, presently located at the BSCS headquarters, who is on leave from Stanford University, California.

Curriculum Design



The BSCS intends to first produce a coordinated series of units dealing with biological science for the secondary school level. In the summer of 1960, a Writing Conference will be held to prepare an initial experimental series of text materials in the form of a number of units, extensive teachers' commentaries, and both block and more conventional laboratory exercises. During the Conference, the personnel of the present committees (Content, Laboratory, Gifted Student, and Teacher Preparation) will cooperate in teams constituted along subject-matter lines in accord with outlines prepared by the Content Committee. Thus, for example, there might be a team on evolution, one on genetics, one on developmental biology, and one on microorganisms. Each team will be composed of approximately four high school biology teachers and four university biologists. Some of the latter will be members of present committees and they will be joined by other college biologists. Participants in the Writing Conference will also include science supervisors, editors, laboratory associates, educational psychologists, artists, and other specialized personnel.

At the end of the summer the provisional units will then be ready for testing during the academic year 1960-61. Near the end of August 1960, and after the Summer Writing Conference described above, a Teachers Conference will be held to acquaint the teachers who will be involved in testing experimental BSCS materials with the rationale underlying various parts of the course. Certain procedural matters concerning the materials will be described, which should help to orient the teachers about to embark on this new experiment.

The over-all plans for testing and revising these materials are as follows: Twenty testing centers located throughout the United States have been selected. Each center will include an active collegiate member of the 1960 Writing Conference. His position will be advisory. The chairman of each center will be a high school biology teacher who will be responsible for the local program. These high school teachers will have been participants at the 1960 Writing Conference.

Each center, then, will have a chairman, about four other local high school teachers of biology, and an advisor from a nearby college. Each week the personnel of each center will meet together for about an hour or two to review material that had been taught previously, and to plan for the coming week. The center leader will be responsible for communicating to the BSCS office specific information about the strengths and weaknesses as they are uncovered in actual classroom use, or what other improvements are needed.

Thus, during 1960-61, the experimental materials will be in use by about 100 high school teachers (with perhaps 12,000 students) organized into about 15 centers. Of the 100 teachers, approximately 30 will have been members of both the Writing Conference and the Teachers Conference. The other 70 will have attended the Teachers Conference. Of the 15 center leaders, all will have been participants at the Writing Conference.

A staff member from the central office in Boulder will be able to visit each center in order to assist in the evaluation and collation of the materials for revision. Later, in the summer of 1961, it will be possible for a second Writing Conference to rewrite and restructure the units wherever the testing

program has indicated changes are necessary. During the academic year 1961-62 the remodeled preliminary units will be available to selected biology teachers who would like to try them experimentally with their classes, as well as at the official Testing Centers. The summer of 1962 will be one in which a third Writing Conference will be involved in the production of final models for the secondary school biology courses. The models will be ready for general distribution and use during 1962-63.

At the present time it is anticipated that the biological materials for both elementary and introductory college levels will be developed under a similar plan, though these programs will lag approximately one year behind that for the high school level.

Cooperative Solutions To Problems

Many high school teachers are now giving good courses in biology. There is no reason why these individuals should feel any pressures for change, real or imagined, when final recommendations are made by the BSCS. There is at the present time perhaps too much of a trend to change for the sake of change without fully evaluating the programs concerned. The BSCS materials will be on the open market and can be adopted or not as seems best locally. There is no desire to promote a national curriculum. It is hoped that the biology courses that are finally recommended by the BSCS will be adopted completely on their own merits. The eventual success of the program seems assured by both the quality of the members of the working committees as well as through a rare enthusiasm which is truly infectious.

The Curriculum Study realizes that there are many problems associated with teaching effective science in the smaller high schools. At the present time there does not seem to be any ideal single solution to many of these problems. In a number of cases, better teacher preparation would do much to improve science instruction. This, and other important problems in science education, will require the attention of many experts and scholars both from within and without the BSCS. Major changes in science education will depend upon the cooperative activities of the various curricular studies, both current and planned, as well as upon teachers, educators, parents, scientists, and administrators.

Small groups, such as the BSCS, can wield great influence, sometimes trigger widespread demands for reform. But the implementation of details for a new school curriculum, for improved professional preparation of teachers, and for the development of community support for the physical improvement of schools requires an uncommon degree of mutual understanding and cooperation by diverse groups interested in better science education. Furthermore, we must not expect betterment to come easily. Many of those interested in the improvement of biological science education recognize that the mere existence of the BSCS offers much promise, but, if necessary, they should also be prepared to make drastic changes from traditional educational patterns and local administrative procedures.

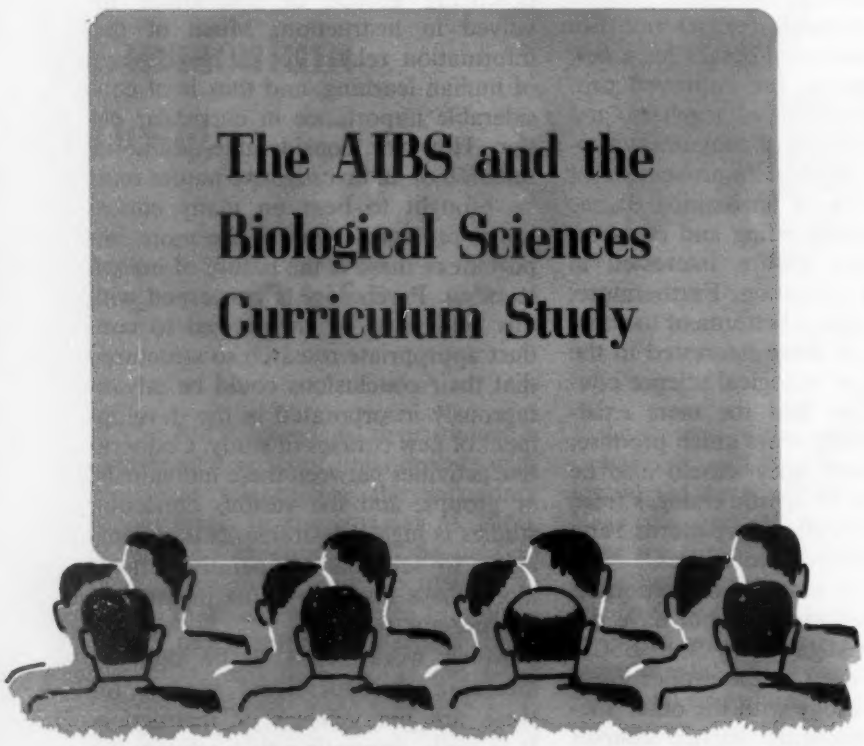
There are a number of important problems which must be, but have not yet been investigated by the BSCS. Two of these are (1) the proper interrelations of biology with the other succeeding or preceding science courses given at the intermediate and secondary school levels, and (2) grade level placement and development of biological concepts from kindergarten through grade 12. Related questions that must be considered by the various BSCS committees and other interested persons are: How can scientists representing all fields of biology best contribute to the development of an improved elementary school program in science? What aspects of the disciplines of biology should be given attention in the elementary school? Is the current pattern of a year of biology, chemistry, and physics in the senior high school satisfactory? Should there be a year of life science in junior high school?

The aspect of education in terms of human learning is an extremely important one in view of a rapidly advancing technology. There is a fair amount of scientific information available on education which has not been utilized by practicing groups of individuals involved in instruction. Much of this information relates to the psychology of human learning, and thus is of considerable importance in curricular design. However, considerable additional research of an investigative nature must be brought to bear on many educational problems. One of the more important of these is the nature of human learning. Psychologists concerned with this field must be encouraged to conduct appropriate research so structured that their conclusions could be advantageously incorporated in the development of new courses of study. Cooperative activities between these individuals, or groups, and the various curricular studies is highly desirable. It is encouraging to see that cooperative efforts along these lines are being initiated at the present time.

Much work needs to be done in the area of educational media, for these are the vehicles of instruction. It is quite interesting that reliance on traditional and unproved educational methodology is slowly being broken down. In cooperation with psychologists, biologists must try to find out how lasting are behavioral changes in student attitudes when different media are exploited in biological science education. How quickly do these changes come about? The tremendous trend to automation through such devices as TV, films, and teaching machines will certainly cause us to look more closely at the role of the individual instructor in the biology classroom. A study of the gifted high school teachers by the BSCS is already under way; results of this investigation may provide the basis for improvements in teacher preparation.

Relation of the BSCS to the Film Series

The relationship of the BSCS to the AIBS-sponsored Secondary School Biological Sciences Film Series has been confusing to some people. The program of the Secondary School Biological Sciences Film Series is to produce on film a modern treatment of classical and contemporary biology designed for the tenth grade. The Series will consist of ten major units of twelve films each. Thirty to forty additional films are planned to supplement and extend the basic 120 films. The Series is not intended to replace the teacher, the laboratory, or field work, but rather to assist and to supplement them. Full production began in July 1959, and the basic Series will be available in either color or black and white. The thirty-minute films will be distributed by the McGraw-Hill Book Company and will be available singly, in sets, or as an entire package. A teacher's manual and student's guide will be included in the Series which is being developed by more than a hundred university biologists and an equal number of secondary school biology teachers. The Film Series (described in the September issue of *TST*) and the Biological Sciences Curriculum Study are two separate AIBS projects aimed at improving biological education in America.



The AIBS and the Biological Sciences Curriculum Study

When the AIBS became an independent organization in 1955, the first standing committee that was established was the one on Education and Professional Recruitment. This action reflected the continuing concern of biological societies and the AIBS Governing Board with education in the life sciences. The charge to that committee was a simple one: develop a vigorous program of education at all levels which would become the basic policy of the Institute. Committee membership has been drawn from persons interested in biological education in universities, liberal arts colleges, land grant universities, high schools, and preparatory schools. Dr. Oswald Tippo, Yale University, has chaired the committee from its establishment.

At the first committee meeting in 1956 it was evident that the committee's major interest was in the improvement of course content and in the development of means to make the teaching of biology more effective. It was suggested that the AIBS sponsor an extensive course content study in the biological sciences, and the committee proceeded to develop an organizational framework for such a program. The proposal to establish the Biological Sciences Curriculum Study was approved as an AIBS project in 1958. In organizing the BSCS and the Film Series the AIBS has, in the minds of interested persons and cooperating professional organizations, come to be intimately identified with biological science curricular studies.

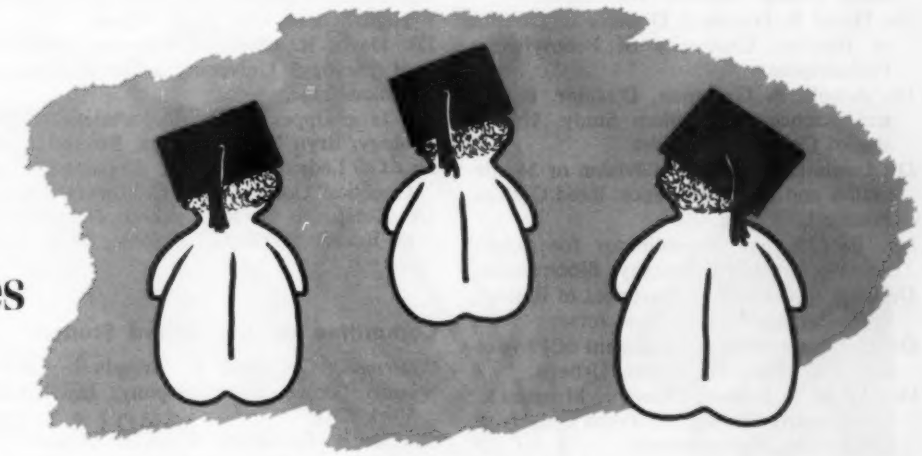
Sponsorship by the AIBS entails a number of advantages which will contribute to the success of the project. First of all, it indicates the deep interest of a group representative of the 80,000 members of AIBS. Through its various media and established contacts, the AIBS can facilitate communication between the Curriculum Study and the nation's biologists. Biologists are being informed of the progress of the Study, and there is resulting considerable feedback of opinions with suggestions and criticisms from the biological community. AIBS sponsorship greatly lessens the danger of imbalance that could more easily develop if the project were associated with a single university. Other interested groups are also kept informed.

Teacher Training . . . a Facet of the BSCS

In order that the BSCS course, or courses, be successfully taught it is essential that teachers have opportunities to become substantially informed about the many modern developments in the life sciences. There are several ways in which this might be done. The BSCS high school biology course could be studied at in-service, summer, and academic year institutes. In addition, the BSCS plans to prepare extensive commentaries for teachers along with the new secondary school unit materials. Still another approach under consideration is the production of a series of review pamphlets, each to be written by an appropriate scholar and devoted to a single topic in the life sciences. These pamphlets would be designed primarily for secondary school teachers, would be well illustrated and well documented. It is intended that they would be issued periodically and that they would be revised as new developments emerge in the fields represented. In this way a high school biology teacher could readily build up an effective professional library giving him considerable depth in the many facets of the subject he is teaching.

Extensive teacher commentaries will also be produced to accompany the text materials and exercises constituting the BSCS recommendations for courses at all levels of instruction.

A New Generation Of Scientists and Their Responsibilities



A tremendous amount of work has already gone into the design of secondary school biology curricula at state and local levels. Much of it is good, sound, and solid. What is the justification then for this new effort by the BSCS, and what advantages over existing biology curricula may accrue from the Study? If there is a single important way in which the BSCS differs in its approach from these many independent studies which have been made over the years by high school faculty members, education faculty members, and state and urban education department staffs, it is that the BSCS involves the active participation of a large number of professional biologists who know the life sciences intimately through first-hand investigations. These biologists bring to the new biology curriculum an exhaustive store of modern knowledge, overview, and perspective that is available nowhere else in our society. The unique aspect of the BSCS is that it brings to a cooperative team the special competencies of the biological scholars in our universities.

The present generation of scientists is beginning to cooperate extensively with teachers and educators as had been customary in the 1800's. There is an unprecedented activity today on college and university campuses where scientists are helping to develop new courses and bring recent developments into the classroom. Examples include the NSF summer and academic year institute programs and the teacher education and professional standards meetings. Biologists are taking an active part in such activities. Summer and academic year institutes, however, though extremely valuable, cannot by themselves introduce large-scale, coordinated curricular revision. That such revision is necessary seems evident.

We must constantly guard against the notion that because of the enormity of the problems associated with a curricular revision on a national scale, they cannot be surmounted. Questions we must ask ourselves are, "Is the planned program a good one?" "Is the recommended curriculum superior to that which is offered in our high schools at the present time?" Only when we can honestly give affirmative answers to both these questions should we begin to become concerned with details of implementation on a local level. We confidently anticipate that students and teachers who will participate in the BSCS course will experience the excitement and thrill of the scientific revolution that is reshaping our modern society. Besides enjoying the satisfaction that comes with acquiring solid knowledge in the life sciences, we hope that they will be able to distinguish between science and superstition and, as citizens, that they will be prepared to act intelligently in the thousand ways in which scientific attitudes are appropriate.

Committee Membership

Steering Committee

Chairman: Dr. H. Bentley Glass, Johns Hopkins University, Baltimore, Maryland.
Dr. Paul F. Brandwein, Harcourt, Brace and Company, Inc., New York City.
Dr. Elmer G. Butler, Department of Biology, Princeton University, New Jersey.
Dr. Hiden T. Cox, Executive Director, American Institute of Biological Sciences, Washington, D. C.
Dr. John Emlen, Department of Zoology, University of Wisconsin, Madison.
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Dr. David R. Goddard, Director of Division of Biology, University of Pennsylvania, Philadelphia.
Dr. Arnold B. Grobman, Director, Biological Sciences Curriculum Study, University of Colorado, Boulder.
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Dr. C. S. Pittendrigh, Department of Biology, Princeton University, New Jersey.
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Miss Ella Thea Smith, Cave Creek, Arizona.
Dr. Herman Spieth, Chancellor, Riverside Campus, University of California, Riverside.
Dr. E. C. Stakman, Department of Plant Pathology and Botany, University of Minnesota, St. Paul.
Dr. William C. Steere, Director, New York Botanical Garden, New York City.
Dr. H. Burr Steinbach, Department of Zoology, University of Chicago, Illinois.
Mr. Hugh Templeton, New York State Department of Education, Albany.
Mr. Richard Trump, Ames High School, Iowa.
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Dr. Perry Wilson, Department of Bacteriology, University of Wisconsin, Madison.
Dr. Herbert S. Zim, Tavernier, Florida.

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Dr. Harry Alpert, Dean, Graduate School, University of Oregon, Eugene.
Dr. Marston Bates, Department of Zoology, University of Michigan, Ann Arbor.
Dr. Ernst Caspari, Department of Biology, Wesleyan College, Middletown, Connecticut.
Mr. Phillip Fordyce, Oak Park-River Forest High School, Oak Park, Illinois.
Dr. David R. Goddard, Director, Division of Biology, University of Pennsylvania, Philadelphia.
Dr. Jane Oppenheimer, Department of Biology, Bryn Mawr College, Pennsylvania.
Dr. G. Ledyard Stebbins, Department of Genetics, University of California, Davis.
Dr. Delaphine G. R. Wyckoff, Department of Botany, Wellesley College, Massachusetts.

Committee on the Gifted Student

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Dr. Florence Moog, Department of Zoology, Washington University, St. Louis, Missouri.
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Mr. Francis Harwood, Director of Publications, American Institute of Biological Sciences, Washington, D. C.
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Dr. Albert Wolfson, Department of Biological Sciences, Northwestern University, Evanston, Illinois.
Dr. Herbert S. Zim, Tavernier, Florida.
Dr. Paul DeH. Hurd, Consultant, Biological Sciences Curriculum Study, University of Colorado, Boulder.

To keep the biological community, educators, administrators, and other interested persons informed of its plans and progress, the Biological Sciences Curriculum Study will issue a series of free NEWSLETTERS.

If you would like to be on the mailing list for BSCS NEWSLETTERS, please send your name and address to:

**The Biological Sciences Curriculum Study
University of Colorado
Boulder, Colorado**

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The Elementary School Science Reporter

Supervision of Elementary School Science: In-Service Courses

By HAROLD E. TANNENBAUM

Professor of Science Education, State University College of Education, New Paltz, New York

DEFINING the role of the elementary school science supervisor has been a matter of controversy for many years. There have been as many interpretations of the specific functions of the supervisor as there have been supervisors in our schools. When this conglomeration of roles is analyzed, however, a definite pattern of functional areas emerges. Enumerating the major ones, we find:

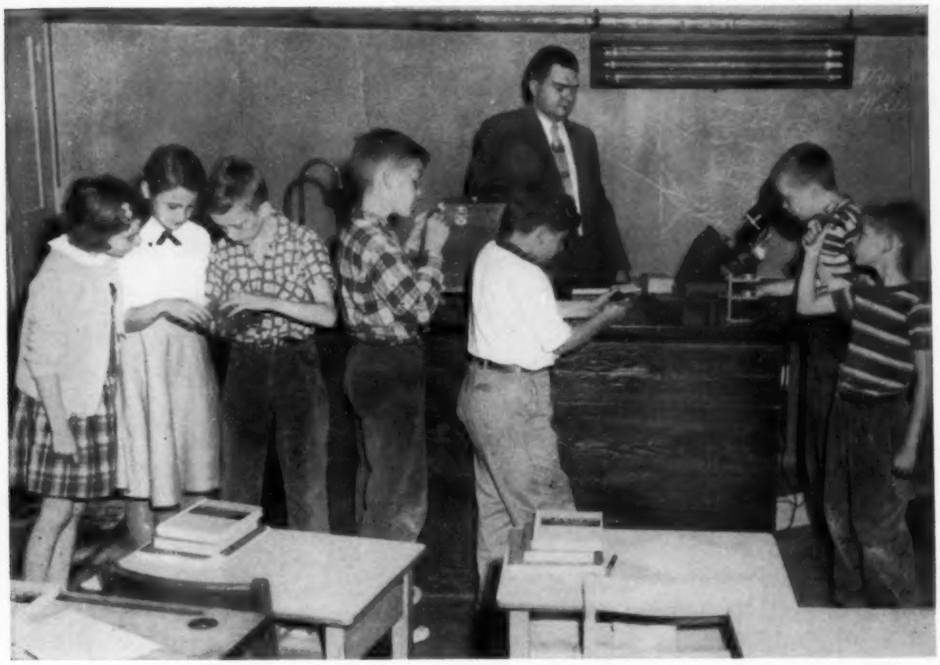
1. The supervisor serves as a science instructor for the teachers in a school system and, either by himself or with the help of outside experts, designs and executes in-service programs in science education for the teachers of the system.
2. The supervisor prepares the curriculum for the elementary school science program or else supervises its preparation.
3. The supervisor serves as the guide for the classroom teacher, helping him see his shortcomings and helping him capitalize on his strengths.
4. The supervisor coordinates the science program of a school or of an entire school system so that a unified program of science is carried out through the grades and the schools.
5. The supervisor serves as the administrator of the science program, ordering the supplies, coordinating the acquisition of materials, budgeting the funds, and seeing that the materials are properly cared for and distributed.
6. The supervisor evaluates the work of the teachers in the area of science and reports to the employing officials the efficiency of any given teacher.
7. The supervisor serves as a science subject-matter consultant—sometimes for the teacher and sometimes for the children.

After-school classes help currently practicing teachers in both content and teaching methods.

Obviously, no one supervisor can perform all of these tasks or fill all of these roles, and each school system has established its own version of the supervisor. But this is all to the good, because different systems have differing needs. A rural county structure will not need the same kind of supervision activities that are required in a comparatively wealthy suburban community. And the functions of supervisors in a large city are quite different from those of supervisors in a town with only five or six elementary schools.

In talking with supervisors from widely scattered geographic regions and various socio-economic communities, the one function which they all feel needs attention is the function of educating currently practicing teachers in both science content and methods of teaching science. The most common procedure followed in fulfilling this need has been the organization of in-service science education courses. At least fifty such courses have come to our attention during the past year, and these fifty are, no doubt, only a small segment of those which have been offered. How have these courses been structured?

While the method of offering each course has varied considerably from one location to another, two general procedures have been followed. Sometimes the supervisor himself has served as teacher of the course. Along with his teachers, he planned, organized, and executed a course in teaching science. School systems all the way from suburban Suffolk County in New York to the Minneapolis city schools to the schools in San Angelo, Texas, have instituted such in-service courses. And there certainly have been others.



Classroom results of in-service programs: new techniques and active student participation.

Another kind of in-service program, while organized by the supervisor in a given community, has been presented by some outside expert, often a college professor. Thus, many extension courses in the teaching of elementary school science have been offered by many universities. And many have been the lectures and one-day workshops which have been sponsored by science supervisors and other school administrators "to bring science into the elementary schools."

Again, taking a census among practicing supervisors, the following opinions have emerged:

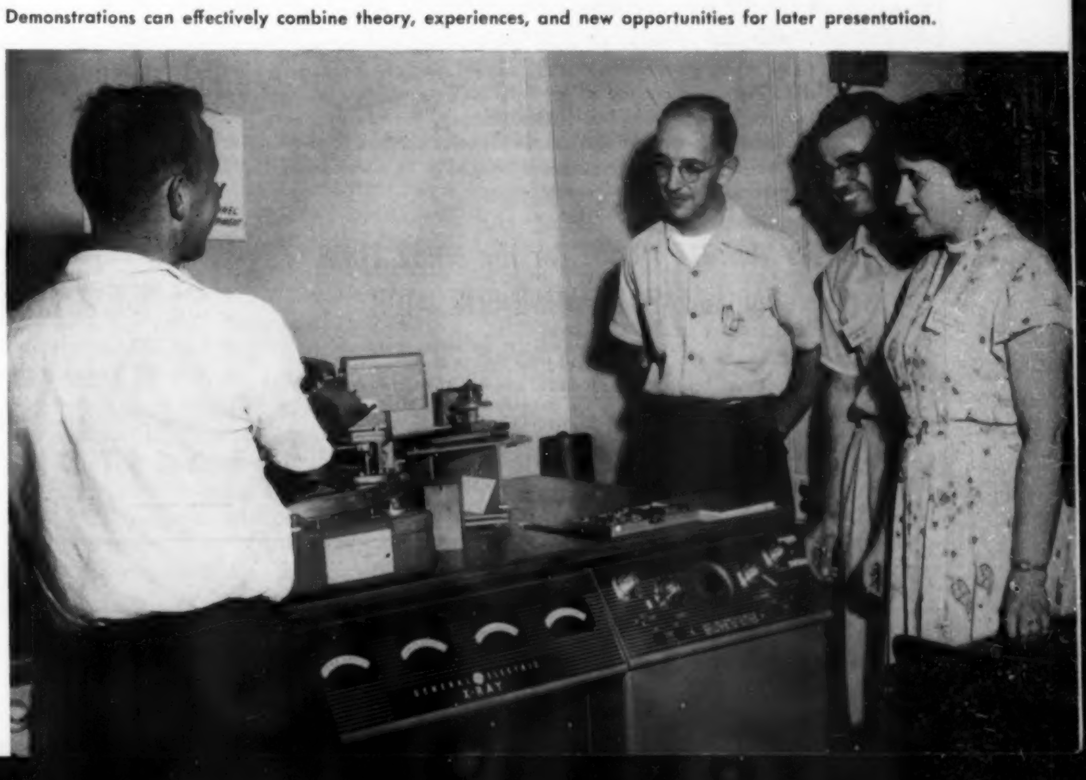
> The effectiveness of an in-service program has been directly proportional to the duration of the program. A one-day shot has had little effect upon the program. Perhaps it salves the conscience of the administrator—but that is all it does. In-service programs which meet once a week for a semester or a year do make a difference, however.
>
> The more teachers who are actively involved in such programs, the more likely is the effectiveness of the program to be felt in the schools. In large school systems, it has been the practice often to have one or two teachers from each school be the representatives at a system-wide workshop. In such cases, unless these teachers then return to their own schools and organize in-service classes for each school, the effects of the program have been limited.
>
> The size of the in-service classes has been very important. Programs which have been limited to twenty-five students have been much more effective than have those which have been established as lectures for larger groups.
>
> The programs that have involved the teachers actively in manipulation and use of science materials have been much more effective than those in which the teachers simply have watched the "expert" demonstrate.
>
> Programs which combine theoretical science *and* actual experiences with materials *and* opportunities to discuss effective techniques for teaching science concepts to elementary school children have been the most effective programs by far.

One thing is clear, however, regardless of what other roles he must play, every elementary school science supervisor must be a teacher of teachers. The variety of techniques which have been employed by school systems for instituting in-service programs has been tremendous. But in all cases, the instructor must not only teach "how to teach science," he must also teach the science itself. A reading supervisor rarely has to teach his teachers how to read. A social studies supervisor generally can spend his time teaching techniques or coordinating programs. But the science supervisor, if he expects his teachers to teach the "science of weather," must first teach this subject matter to the teachers, and then help them learn how to present it to children.

Supervising elementary school science is a tremendous task. Through the columns of "The Elementary School Reporter" we will examine what has been done in various other phases of this work, and report significant programs in forthcoming issues.

We would like to hear from supervisors, teachers, and school administrators from all over the country about the specific successes or failures they have had with science supervisory programs. It is our hope that through such sharing of experiences, some advances can be made in the art of supervision.

Demonstrations can effectively combine theory, experiences, and new opportunities for later presentation.



NSTA Activities

Chapters and Affiliates

One of the major decisions relating to NSTA's future development and growth will be hammered out by the Board of Directors at Los Angeles next summer. The question is, should NSTA, with the cooperation of appropriate groups, proceed to establish state chapters? Present provision for affiliated group status would be continued for organizations at local, regional, national, and international levels.

NSTA state chapters would *not* compete with present state associations or groups. On the contrary, it would be hoped that these very organizations would serve as NSTA state chapters; most are affiliated with NSTA already.

The major purposes in these considerations are: (1) to develop better definitions of appropriate state and national activities; (2) to strengthen state and national relations and improve the coordination of efforts; and (3) to develop a "stronger voice" for the united science teaching profession. It is rather interesting to note that the stronger, influential departments of NEA do have provisions for state chapters or their equivalent.

The question facing NSTA has been explored with representatives of 22 states in five conference situations. An opinionnaire presenting 17 tentative proposed criteria or principles for a state chapter plan has been submitted also to about 200 persons, including presidents of NSTA's 72 affiliated groups, 25 state supervisors of science, and a sampling of the membership at large.

Replies have been received from 41 per cent (82) of these individuals. Preponderance of opinion on representative items is as follows:

93 per cent believe NSTA *should* establish state chapters.

72 per cent believe *affiliation* should be continued for certain non-state groups.

83 per cent say that *existing state organizations* should be encouraged to become state chapters of NSTA.

87 per cent say that *autonomy* of state groups must be assured.

80 per cent favor a "representative assembly" (or similar) plan to afford meetings of delegates of chapters and affiliated groups with NSTA Board of Directors.

47 per cent believe that NSTA should give some form of financial assistance to state chapters.

69 per cent believe NSTA should invite certain associations of science teachers in other countries to affiliate.

The Board of Directors needs and will appreciate advice and viewpoints as they ponder what action to take. Three or four state associations have already requested the honor of receiving State Chapter Charter Number 1. Opposition to the idea has been expressed in strong terms in some instances. Numerous possible pitfalls and devious situations have been flagged. Additional comments and suggestions are solicited. Write your views to the Executive Secretary, or, if you prefer, request a copy of the opinionnaire to mark and return.

Convention, 1961

The dust has hardly settled on the Kansas City convention, yet planning for 1961 in Chicago is well under way. As a matter of fact, President-Elect Robert A. Rice and Convention Chairman Oreon Keeslar pulled their committee together for a first work session in Chicago last November 13-15. The theme and general design for 1961 have been set, and responsibilities for various sessions have been assigned to committee members. Invitations to speakers and other hoped-for participants are to be issued during the coming months.

This is not to say, however, that everything is "cut and dried," that the door to suggestions is closed. On the contrary, speakers you would like to hear, persons you wish to suggest for panels, etc., and the kind of program items you prefer would be helpful to the committee. If you wish to participate, let this too be known. Write directly to Dr. Oreon Keeslar, Santa Clara County Schools, 2320 Moorpark Avenue, San Jose 28, California.

Membership Year

Your membership in the National Science Teachers Association runs for one year from the month payment of dues is received by the Membership Secretary, Mrs. Edith M. Langley. This policy represents a change in the pattern of memberships which was previously based on a December expiration date.

Membership renewals will now be spread over the entire calendar year thus lightening the work load in the headquarters office and providing better services to you. You can make your contribution by renewing your membership promptly upon receipt of your notice. This may be done on a one- or two-year basis; changes in type of memberships may be made at that time.

If questions about your membership payment or services arise, write to the headquarters office bringing the matter to the attention of the Membership Secretary (Mrs. Langley nee Nicholas).

Council for Research

In January the National Science Teachers Association joined with nineteen other professional organizations to form the Council for Research in Education. Continued efforts will be made to enlist the interest of other organizations which can bring an interdisciplinary approach to the study of school and college problems. Currently, many of the departments of the National Education Association are represented together with the American Psychological Association and the American Statistical Association.

The purpose of the Council is to advance the standards of educational research, to improve the preparation of research workers, to distribute information concerning the need for research and the progress of research, and to help research workers find funds for outstanding or needed studies. The Council is not intended to become a research agency. A definitive program will be worked out by the Committee on Research and Review under the chairmanship of Herbert A. Smith, Past President of NSTA.

Officers of the Council include: Kenneth E. Anderson, *Chairman* (representing the National Association for Research in Science Teaching); Boyd Harshbarger, *Vice-Chairman* (representing the American Statistical Association); Frank W. Hubbard, *Secretary* (representing the National Education Association); and John G. Darley, *Treasurer* (representing the American Psychological Association). Other members of the Board of Directors are: Maynard Bemis (representing Phi Delta Kappa); Howard McClusky (representing the Adult Education Association); and Percival M. Symonds (representing the American Educational Research Association).

FSA Activities

SAAS, 1960

Winners of the 1960 SAAS contest have been selected and announcements of the final results are in preparation for early distribution.

In each of eleven regions a group of scientists, science educators, and science teachers, acting as judges, have met and evaluated the various projects submitted in the respective regions. These judges get no honorarium, no metals, no plaques. They donate their time and talent because they feel that this is a program that is increasing the "science quotient" of today's secondary school students. This is a contribution meriting attention and appreciation.

The responsibility for organizing and carrying out the program in each region rests with the regional chairman. He, too, donates his time and talent to the program. After the judges have finished their work, the chairman sends the reports, projects, etc., to NSTA headquarters. These chairmen are the SAAS indispensable men. Their reward is in the satisfaction of a job well done as evidenced by the results. Their efforts are sincerely appreciated. Listed below are these eleven regional chairmen.

SAAS Indispensable Men

Region I
Edgar N. Johnson
West Springfield High School
West Springfield, Massachusetts

Region II-A
Samuel W. Bloom
Benjamin Franklin High School
Rochester, New York

Region II-B
David McNeely
Summit High School
Summit, New Jersey

Region III
John B. Chase
University of North Carolina
Chapel Hill, North Carolina

Region IV
Paul L. Guptill
Station WETV
Atlanta 9, Georgia

Region V-A
Leroy Heinlein
Cincinnati Public Schools
Cincinnati, Ohio

Region V-B
Edward Victor
Northwestern University
Evanston, Illinois

Region VI
Michael Foss
Augustana College
Sioux Falls, South Dakota

Region VII
Alan Humphreys
University of Texas
Austin, Texas

Region VIII-A
John Hutchison
Portland Public Schools
Portland, Oregon

Region VIII-B
Eugene Roberts
Polytechnic High School
San Francisco, California

Roster of Sponsors

The list of sponsors for the 1959-60 FSAF program continues to grow. Since reporting in the February issue of *TST*, these organizations have been added to the roster.

Armco Steel Corporation
The Maytag Company Foundation, Inc.
Raytheon Company
Rohm & Haas Company
Standard Oil Company of New Jersey

Through February 10, 1960 our total member contributors have supported FSAF with a total of $22,190.

Research Participation

The San Francisco Aquarium Society has generously donated $3000 to support the FSAF program of on-the-job research experiences for teachers and students. This sum will be allocated to support research proposals submitted to NSTA by California science teachers. If you have a research project which you and your students have not been able to complete for lack of funds—here is your opportunity. Write to NSTA headquarters to get directions for submitting your proposal.

Annual Spring Meeting

On April 29-30, 1960, the FSAF Administrative Committee will hold its annual spring meeting. The first day of this meeting will be open to all sponsors and friends of FSAF who are interested in the program of the Foundation. Discussions will include accomplishments of the year, suggestions for the coming year, industry and the FSAF program, and other topics that are presented.

On the second day, the Administrative Committee will meet to plan the 1960-61 program and to determine the budget needs for the year. You are urged to submit your ideas for FSA activities for consideration of the committee.

FSA Publications

Booklets produced under the sponsorship of the Foundation continue to be among NSTA's best selling publications. It is a safe bet, for example, that *Keys to Careers* must be serving an extremely useful purpose. This bibliography of career information and guidance materials is now in its fifth edition and nearly 200,000 copies have been printed and distributed. (Single copies are available for 10 cents each.)

Approaching the 200,000 mark, also, is the current edition of *Careers in Science Teaching*. (Single copies are available free of charge, and additional copies for 10 cents each.)

About 50,000 students have purchased copies of the FSA publications which give ideas and procedures for doing student science projects. These include *If You Want to Do a Science Project* and *Encouraging Future Scientists: Student Projects*. (Both are available for 50 cents each.) These two booklets may prove stimulating and useful to science-minded students who want to plan a project during the summer months.

SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee
Dr. Robert A. Bullington, Chairman
Northern Illinois University, DeKalb

BOOK BRIEFS

The Rock-Hunter's Field Manual. D. K. Fritzen. 207p. $3.50 Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1959.
For the use of the amateur in the field or at home. Contains a useful key to 126 minerals based primarily on color but also using properties of luster, streak, hardness, and fracture. Includes alphabetical listing of minerals with description and explanation of uses.

Of Things Bi-Illogical. Bernal R. Weimer. 70p. $2.25. From the author, Bethany, W. Va. 1957.
An entertaining collection of amusing verse, cartoons, anecdotes, and excerpts from students' written work and oral comments, all touching on some phase of biology.

Let There Be Light. Lillian J. Bragdon. 92p. $2.75. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1959.
Covers the many fascinating aspects of lighting from its very beginning with primitive man and into the future. History of lighting is revealed in a simple way.

The Spanish Plateau: The Challenge of a Dry Land. Peter Bickley. 96p. $2.50. Coward-McCann, Inc., 210 Madison Ave., New York 16, N. Y. 1959.
The story of the difficult life of the people on the arid plateau of Spain. The climate, topography, soils and agriculture, and problems of irrigation are interestingly described for the juvenile reader from 10 to 15. Illustrated with excellent photographs by the author.

Our World of Science. Duane Bradley and Eugene Lord. 160 p. $3. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1959.
Book explains some of the aspects of the physical sciences, such as sound, light, air, water, motion, gravity, heat, electricity, and magnetism. Gives clear explanations of facts underlying these phenomena. Can be used by young boys and girls, as well as by parents.

All About the Ice Age. Patricia Lauber. 152p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1959.
Poses interesting questions about the ice age. Includes story of Louis Agassiz's pioneering study of this interesting era as well as the work of modern scientists. Describes origin, movement, and work of glaciers. Life in the ice age, fossils of the period, and carbon dating are explained. Explores possibilities of future periods of glaciation. Illustrated, drawings. Interesting reading for all ages.

Readings in the Literature of Science. William C. and Margaret Dampier. 276p. $1.50. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1959
This anthology, long a classic in the history of science, possesses the happy virtue of coherency in the development of science's more important problems: cosmogony, atomic theory, and evolution. The extracts, with these fields, have been selected so as to afford the reader a better understanding of the total scientific process. A desirable addition to either a private or public library.

The Story of Earth Science. Horace G. Richards. 170p. $3.75. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1959.
Written for the layman about rocks, fossils, and minerals. The book has selected the more common examples of the areas treated. These are described and explained with an element of simplicity which invites the continued attention of the lay reader. An elementary basis is laid for further study of each of the items described.

Science and Resources: Prospects and Implications of Technological Advance. Edited by Henry Jarrett. 250p. $5. Resources for the Future, Inc., The Johns Hopkins University Press, Baltimore 18, Md. 1959.
Contains 18 short essays by authorities in as many fields. The papers were originally delivered to the 1959 Resources for the Future Forum. Major topics treated are genetics, weather modification, mineral exploration, chemical technology, nuclear energy, and the space program. Obviously, the series is neither exhaustive nor comprehensive; but for the areas listed this compendium puts between two covers many facts and ideas otherwise available only from widely scattered sources. True to RFF tradition, both natural and cultural aspects of a development receive attention. RFF has resisted our modern tendency to shake human dignity in a test tube and pour it down the drain!

The Logic of Scientific Discovery. Karl R. Popper. 480p. $7.50. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1959.
Popper's own translation of his provocative *Logik der Forschung,* long recognized as an important work in philosophy of science. Contains a most interesting theory of falsification by which the author attempts to bypass the problem of induction. His success at this may be disputed. Discussion of basic statements is original and stimulating but

unfortunately brief at the points of greatest vulnerability. Contains much interesting material on testability, simplicity, probability, and corroboration. Presupposes an acquaintance with formal logic and epistemology.

Human Heredity. Ashley Montagu. 398p. $5. The World Publishing Company, 2231 West 110 St., Cleveland 2, Ohio. 1959.
A volume readable by the interested high school student and acceptable to the professional. It is a well-considered discussion of the hereditary and environmental determination of human development, treated in the light of modern social and international conditions. Should prove an eye-opener to many biologists.

Brimstone: The Stone That Burns. William Haynes. 308p. $5.95. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J. 1959.
Brimstone is a book which brings up-to-date the story of sulfur originated in the book entitled *The Stone That Burns,* published in 1942. It brings the story from sulfur resources of the Louisiana swamps through its years of development to the present-day sulfur recovery practices employed in France and Canada. The book is filled with specific facts about places as they are related to the recovery of sulfur today.

Earth Science: The World We Live In. Second Edition. Samuel N. Namowitz and Donald B. Stone. 614p. $5.20. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J. 1960.
This is an expanded second edition of a high-ranking text for junior high school courses in the Earth Sciences. Includes an extra chapter on economically important minerals, four chapters on earth history, and several color plates, a complete glossary, and an appendix containing a table of mineral identification properties.

The Education of Teachers: Curriculum Programs. 464p. $3.50. National Commission on Teacher Education and Professional Standards (TEPS), National Education Association, 1201 16th St., N.W., Washington 6, D.C. 1959.
Proceedings and report of the 1959 TEPS Conference at the University of Kansas, Lawrence, Kansas. The second in a series of three cooperative national conferences, the Kansas Conference was devoted to the changes necessary in teacher education curricula to provide outstanding teachers for the future. Included are the conference and section addresses; summaries, analyses, and recommendations stemming from group discussions; and all of the conference working papers.

PROFESSIONAL READING

"Paperbound Books in the History and Philosophy of Science." By L. E. Klopfer. Harvard Graduate School of Education, Batchelder House, 7 Kirkland St., Cambridge 38, Mass. 1959. Prepared for high school science teachers as a guide to suitable, inexpensive books in the history and philosophy of science and biographies of scientists. Approximately 200 titles are listed; some are annotated; all have an indication of the content and language difficulty. Single copies are available for 10¢ from the author.

"Science on the Horizon." Office of the Director of Science, Board of Education of the City of New York, 110 Livingston St., Brooklyn 1, N.Y. January 1960. Report of proceedings of the New York City Science Institute for the formulation of guidelines for a sequential K-12 science program held in August 1959. Topics include the rationale,

goals, and implementation of a K-12 science program as well as the conclusions of the Institute's participants. A limited number of copies are available from the Board of Education.

"Low Achievement: A Memorandum and Bibliography." Bureau of Curriculum Research, Board of Education of the City of New York, 110 Livingston St., Brooklyn 1, N. Y. March 1960. Objective, evaluative study of low achievement pupils in the public schools. The report defines low achievement and gives a good history of the subject from the 19th century until modern times. Research studies both past and present from all types of schools are included and statistical summaries show that statements are based on fact. A discussion of vocational high schools and an excellent bibliography round out a very informative review of low achievement in pupils. Single copies are available for 35¢ from the Publications Sales Office, Board of Education.

"Selected Bibliography for Curriculum Workers . . . 1960." Association for Supervision and Curriculum Development (ASCD), National Education Association, 1201 16th St., N.W., Washington 6, D.C. 1960. Collection of curriculum references representing the most significant books, pamphlets, monographs, and articles which appeared during 1959. Subject areas include educational foundations; curriculum organization and development; elementary and secondary instruction in language arts, mathematics, science, and social studies; and special areas of instruction and education. Single copies are available for $1.

"Curriculum Materials 1960." Association for Supervision and Curriculum Development (ASCD), National Education Association, 1201 16th St., N.W., Washington 6, D.C. 1960. Representative listing of curriculum guides currently being produced by school systems, state departments of education, and colleges engaged in teacher education. Includes complete information on securing all bulletins: address, level or grade, availability, date of publication, and price. Single copies are available for 75¢.

"The Role and Training of the Physicist in Industry." By seven selected industrial leaders. *Physics Today,* 13:23. January 1960. This series of seven selected articles is based on addresses given by industrial leaders at an October symposium held by the American Institute of Physics. The participants, representing fields from automobiles to satellites, offer through these articles guidance of value to science teachers who are counseling the students to train in physics for industry.

"Truth in Physics." By Paul F. Schmidt. *American Journal of Physics,* 28:24. January 1960. When can physical law be accepted as true? Is a theory necessary before the truth of a law can be tested? Are the standards that are used for finding truth in physics applicable to the field of philosophy? These are the basic questions around which this article is written. This is a logical, nonmathematical example of the scientific process.

"Careers for Women in the Physical Sciences." Women's Bureau Bulletin 270. U. S. Department of Labor, Washington, D. C.

1959. Because of today's critical need for qualified scientists, careers for women are abundant in such fields as chemistry, physics, geology, astronomy, and meteorology. This report outlines the basic preparation recommended for a scientific career, the job outlook in a few major scientific areas, the kind of work available for qualified women scientists, and the rewards such work offers. Data are also given on the employment, education, types of work, and characteristics of women scientists. Reports are available at 35¢ each through the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

"Analysis of Research in the Teaching of Science July 1956-July 1957." By Ellsworth S. Obourn and Charles L. Koelsche. U.S. Department of Health, Education, and Welfare Bulletin 1960, No. 2, Washington, D. C. Bulletin summarizes and interprets the research findings in science education on the elementary, secondary, and college levels. Studies were related to such topics as science curriculum, teachers and teacher education, procedures, methods and resources, texts and syllabi, and science achievement. Recommendations for all levels are included. Bulletin available for 25¢ each through the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C.

"The Chemical Industry Facts Book 1960-61." Fourth Edition. Manufacturing Chemists' Association, 1825 Connecticut Avenue, N. W., Washington 9, D. C. 1959. Describes

the chemical industry in the United States and how it operates, chemicals in everyday life, and chemicals in the service of man. The future of the scientific world, especially the chapters devoted to "Chemicals and Nuclear Energy" and "Chemicals and Space," are of special interest to teachers and pupils. A comprehensive teachers' guide, prepared by Donald G. Decker and John A. Beel, accompanies the "Facts Book." Copies are available at $1.25 each through the Manufacturing Chemists' Association.

"The Arms of the Galaxy." By Bart J. Bok. *Scientific American,* 201:93. December 1959. Discusses the experimental work that is being carried on to test the hypothesis that our galaxy is a giant spiral. Diagram and pictures make the article very valuable.

AUDIO-VISUAL AIDS

Reproduction in Plants. A survey of asexual and sexual plant reproduction for high school use. Includes reproduction in some algae and in lilies, cross fertilization, and vegetative propagation. Best used as a review of basic processes. 13½ min. Color $137.50, B&W $75. 1958. Coronet Films, Coronet Building, Chicago 1, Ill.

Heart, Lungs and Circulation. For such a broad topic, this film covers a surprising amount of information. The graphic work is clever and lifelike, with paints used on a boy to show circulatory routes. Dialogue excellent. Color recommended for full effect. Suitable for middle and upper grades. 11 min. Color $110, B&W $60. 1959. Coronet Films, Coronet Building, Chicago 1, Ill.

Flowers and Plant Reproduction. A color filmstrip which uses labelled drawings to show flower structure, pollination, fertilization, and development of seed and fruit. Useful aid in junior and senior high science. User should be aware of some minor inaccuracies. 31 frames. $6. 1959. Kapin Educational Productions, 5843 Cedros Ave., Van Nuys, Calif.

Science Seminar. Originally shown on television, this film was made to explain the "Berg Plan for the Advancement of Science." Shows the plan in operation in the Gary, Indiana, schools. The purpose of the program is the education of science-talented youth through the volunteer efforts of scientists from business, industry, and universities. Film is available to any school or community group interested in the development of special science programs for high school students. 25 min. Free. The Joe Berg Foundation, 1712 South Michigan Ave., Chicago 16, Ill.

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor as early as possible.

June 29, 1960: NSTA Annual Summer Meeting with National Education Association, Los Angeles, California; Luncheon meeting and afternoon session

June 29-July 1, 1960: Annual Business Meeting of Board of Directors, Los Angeles, California

September 9-10, 1960: NSTA Regional Conference, University of North Carolina, Chapel Hill

October 28-30, 1960: NSTA Regional Conference, Deauville Hotel, Miami Beach, Florida

December 26-30, 1960: NSTA Annual Winter Meeting with the American Association for the Advancement of Science, New York City.

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